TRANSACTIONS

OF THE ILLUMINATING ENGINEERING SOCIETY

"......the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto"

Featuring

Stage Lighting Papers

By Rothafel and Hartmann

Sky Brightness Report

VOL. XVIII. MAY, 1923. NO. 5

SEVENTEENTH ANNUAL CONVENTION, I. E. S.

LAKE GEORGE, N. Y., SEPT. 24-28, 1923

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

Vol. XVIII MAY, 1923

TABLE OF CONTENTS

Individual Responsibility in Making I. E. S. Activities Beneficial — J. L. Stair

Important Advances in Street-Lighting Equipment
Back to Candles
New York City has Novel Electric Sign
Relative Effectiveness of Direct and Indirect Illumination

Artistic Color Lighting in Motion Picture Theatres — S. L. Rothafel
Lighting Effects on the Stage — Louis Hartmann
Discussion of Stage Lighting Papers
Report of the Committee On Sky Brightness — H. H. Kimball, Chairman

Abstracts

Society Affairs

Illumination Index

PUBLISHED MONTHLY EXCEPT JUNE AND AUGUST BY THE
ILLUMINATING ENGINEERING SOCIETY
PUBLICATION OFFICE, EASTON, PA.
EDITORIAL OFFICE, 29 WEST 39 ST., NEW YORK CITY

ENTERED AS MATTER OF SECOND CLASS AT THE EASTON, PA. POST OFFICE.
ACCEPTANCE FOR MAILING AT SPECIAL RATE OF POSTAGE PROVIDED FOR IN SECTION 1103, ACT OF OCTOBER 3, 1917, AUTHORIZED JULY 16, 1918

REPRINTS ORDERS

In order to minimize the expense of holding type, the printer has been instructed to throw the pages of the TRANSACTIONS shortly after publication. Authors wishing to secure reprints at the minimum rate should notify the General Office in advance. For reprints ordered after publication in the TRANSACTIONS, a higher fee must be charged.

MEMBERSHIP LIST

There will be printed a new membership list as of June 15, 1923. Please send immediately any change in address, business connection, or occupation to the General Office.

OLD TRANSACTIONS WANTED

TRANSACTIONS for October, November and December, 1922, and January, 1923, are out of print. Please advise the General Secretary of any of these issues for sale and price will be quoted.

COMMITTEE ON EDITING AND PUBLICATION.

TRANSACTIONS
OF THE ILLUMINATING ENGINEERING SOCIETY

VOL. XVIII MAY, 1923 NO. 5

Individual Responsibility in Making I. E. S. Activities Beneficial

BECAUSE OF the fact that from the very start an unusually high standard has been maintained for the material that appears in the TRANSACTIONS, we can proudly boast that the official publication of our Society forms the most important and valuable collection to lighting literature in the world.

The bulk of the burden of providing the necessary material to maintain this high standard, falls upon a few committees, one of which is the Papers Committee. The Committees, therefore, should have the fullest co-operation of the entire membership. They should receive from time to time frank suggestions; ideas for the improvement of the TRANSACTIONS and for material that is to be included in them.

One of the big events in our Society affairs—one that we all look forward to—is the national Convention. The program for the 1923 annual meeting is rapidly taking form and in order to make this Convention program, "of, by and for the membership," we want your early suggestions.

Do you know of or have you been making a recent valuable investigation? If so, notify the Papers Committee.

Have you heard of some remarkable development in lighting devices or applications? If you have, send a brief note concerning it to the Committee.

Can you suggest a subject that combines a practical idea with an entertainment feature? We need it to round out the program.

Can you suggest anything that you believe should be investigated—a contemplated research, or ideas that you think would be the basis for a real contribution to lighting literature?

The Committee has on hand a list of possible subjects for papers that have come in from various sources. The nature of the subjects so far received, indicate that material will be available to make the coming Convention—from the standpoint of the Papers program—a wonderfully interesting and valuable one.

We have a selection of papers of a purely scientific nature—those that will record in minute detail some of the most recent technical phases of our lighting science.

A number of excellent subjects have been received that might be designated as practical subjects—discussing the correct applications of good lighting principles.

There are some ideas for semi-scientific discussions, as well as a number that might logically be called "general interest topics." A few of the latter can easily take on the nature of a demonstration lecture and thus be made to present valuable information in a very entertaining way.

It is the purpose of the General Papers Committee to provide for the fall convention a perfectly balanced program, one that will give the proper consideration for both scientific and so-called practical subjects. The program will not be crowded. Ample time will be reserved for discussions—a most essential part of the program. The tentative program for the fall convention is rapidly being completed.

Suggestions from every member of the Society as to how the program can be improved are urgently requested. Ideas for papers to be included should be forwarded to the Committee chairman without further delay if they are to be considered. Most every year topics of value must be omitted because they have been sent in too late.

J. L. STAIR, *Chairman,*
Committee on Papers.

REFLECTIONS

Important Advances in Street-Lighting Equipment

DREARY standardization of street-lighting equipment has been threatened of late, and therefore it is refreshing to find that a step forward is actually being taken, one in a direction already familiar, the automatic operation of sub-stations combined with out-door apparatus. The progress referred to has been achieved in Kansas City and is described by A. E. Bettis in the *Electrical World,* February 10, 1923.

Time was not many years ago when the suggestion of placing even switches and transformers out of doors was regarded as a dangerous heresy, stamping the engineer who proposed it as a harebrained innovator who should promptly be suppressed lest he break in on the beautiful symmetry of catalog equipment. But the world moves, and as time has gone on more and more apparatus has gone out of doors, sometimes indeed more than under the local conditions might always be desirable. The radical departure in Kansas City lies in placing the constant-current transformers and their immediate equipment on the line poles at convenient outlying points for the supply of the street-lighting circuits. To feed and control these a single 4,000-volt, three-phase, four-wire circuit is run out of each of seven general sub-stations. The several phases are distributed as 2,300-volt feeders in three symmetrical territories around each sub-station. In the automatic street-lighting units the line feeder is connected as usual, but is controlled by a time clock which operates the master controller, energizes the circuit and puts the equipment into operation. The same time clock takes the street-lighting circuits off by opening the control circuit and thus checking the activities of that particular feeder. The ordinary constant-current transformer used in this way is rated at 20 kva., smaller units being employed in some of the outlying districts. Each of these 20-kva. installations is good for about forty 600-cp. lamps or a proportionately greater number of 400-cp. or smaller sizes. As there are more than six thousand lamps in all, of which more than half are of 600-cp., the thorough subdivision of the transformer system is self-evident.

This automatic service does two very important things. It eliminates a serious amount of equipment in the sub-stations, necessarily well filled with apparatus for other purposes and, what is even more important, it gets rid of the long and troublesome dead runs of wire on the street-lighting circuits. Any one who is familiar with the complication of laying out street-lighting circuits which have to be operated from one or a few sub-stations will realize the value of pole equipment for handling comparatively short circuits automatically. In this way one can get the maximum number of lamps per actual mile of circuit and avoid contingencies which might put out of action a large portion of the circuit at once.

The other outstanding feature of the Kansas City installation is the underground cable work. The city was not provided with the conduits adequate for the new system even if it had been desired to use them, and it was desired to get rid of overhead wires in so far as this was humanly possible in a growing installation. The difficulty was met by a special lead-covered cable laid over with a triple jute covering impregnated with insulating compound. The chief purpose of the jute covering is to check danger from electrolysis. The cables are paper-insulated, carrying a single No. 8 conductor, and the experience of a year with this cable, of which 750,000 feet are now under ground, has been entirely satisfactory. It is laid directly in earth in a narrow trench 12 inches or 14 inches deep, and at street intersections an additional protection is installed in the form of a 2-inch fiber contact. Special lamp posts are used only where there are no trolley poles handy. Where these are available a special bracket carries the lamp. This arrangement of cable for the underground supply of street lamps has proved to be reasonably cheap. The cost of trenching, placing and filling is running less than 10 cents a foot in clear ground, while the typical total installation cost is reckoned at about 23 cents per foot exclusive of street crossings. Very little trouble has been had with the underground system, and experience indicates that no serious difficulty is to be anticipated.

Of course, the critical period for any such installation is after some years of service, and future results will be watched with interest. Enough has been done, however, to show not only

that a thoroughly practical system of automatic pole transformers for street-lighting service can be used but that supply by underground cables laid simply in the earth is here, as it it has been proved in various places abroad, an entirely satisfactory means of getting the wires out of the way.

Back to Candles

ELECTRICITY is blinding mankind. If modern man wishes to preserve his eyesight he must take a long step backward, stop using electric lights and return to the use of candles. This is the statement of an English scientist.

Fifty per cent of men, he says, wear spectacles to-day, 20 per cent of women and many children. The principal reason for this condition, according to the scientist, is that the eyes of man for many generations have been accustomed only to the soft light of the open fire or the candle's gleam and are not fitted to withstand the brilliancy of electric light.

There is something to be said for this theory. Long exposure of the eyes to glaring light is trying and undoubtedly fosters visual troubles. It is true also that because of better lighting facilities people use their eyes for more hours out of the 24 and weary them proportionately. On the other hand the effort to use the eyes in a poor light, particularly for close work, is swiftly productive of bad vision.

The solution hardly lies in a return to candles. It lies rather in a wise softening of the electric glare and in a more sane observance of hours of rest from both light and eye-strain. More than all it lies in a careful observance of proper placing for all lighting fixtures with relation to the work in hand.—Editorial, *Ithaca Journal-News,* April 4, 1923.

New York City Has Novel Electric Sign

AN electric sign of novel and artistic type has been erected along the canyon of white lights on Broadway, New York, to announce a popular motion-picture entitled "The Covered Wagon." The wagon and entire upper portion of the sign are lighted by ten 500-watt flood-lamps, and on the front of the wagon is a lantern which is an exact facsimile of the type used in 1849. A lighting effect which simulates water running under

the wagon is obtained by six stereopticons automatically operated by motors which turn a color wheel with water painted on it. Each lamp is a 2,000-watt nitrogen-filled unit specially made for stereopticon purposes. In the center of the water is a small sign in raised bronze letters reading "Paramount Pictures." These letters are set in a box flush with the water and are illuminated by indirect lighting which causes the letters to stand out as if they were set in the water.

Relative Effectiveness of Direct and Indirect Illumination

NO SUBJECT connected with illumination has been the cause of more controversy than the relative merits of direct and indirect lighting. The quarrel has not been merely a commercial one such as might be reasonably expected, but a technical one also, and in that aspect there is less reason for variations of opinion. A number of so-called practical studies have been made dealing with the properties of light falling directly on the page and falling upon it after reflection from the walls and ceiling, and utterly diverse data have been obtained. The probable cause of these striking discrepancies is the fact that any investigation of this sort tends to emphasize psychological rather than physical values, values therefore determinable only in vague impressions of comfort and discomfort, of ease and difficulty, of fatigue and facility.

In any tests made upon the eye other factors than the ordinary ones of shade perception and acuity of necessity enter. The particular kind of work attempted, the extent to which the several illuminations are pushed above the limit for moderate acuity, the contrast of the things observed and the length of time for which the observations may be continued, all are things which enter the final judgment as to the sufficiency of the illumination received. There is added to these causes of uncertainty a still greater one in the element of unconscious suggestion in the manner of the test or the instructions given for carrying it out. It would not be difficult to make a given group dissatisfied with almost any system of illumination without an expressed word of disapprobation. As a matter of fact there can be no sweeping decision between direct and indirect lighting. Some of the worst and some of the best examples of illumination alike belong to each.—Editorial, *Electrical World,* April 28, 1923.

PAPERS

ARTISTIC COLOR LIGHTING IN MOTION PICTURE THEATRES*

BY S. L. ROTHAFEL**

SYNOPSIS: Mr. Rothafel's lighting effects at the Capitol Theatre are the result of study of the psychology of the audience. He has found that the ideal lighting arrangement is soothing to the mind and nerves and at the same time stimulating to the imagination. As illustration of his methods he describes the way he builds up lighting effects for various units, or parts, of a program.

The theatre of to-morrow, which will be very different from that of to-day, Mr. Rothafel predicts will depend almost entirely upon lighting for scenic effects, and this lighting will be controlled from one unit.

I am going to make a confession to you before I start, and that is, I don't know anything at all about lighting, and don't know anything about color. It just happens—that's all. I am going to try to tell you how it happens. If I were to attempt a discourse on the technical part of what we are doing, (I will use the personal pronoun) I am doing, I am afraid I would get into deep water.

The lighting, the equipment, and the various things that we have done, came to me just as naturally as the music has come, and before I launch into the lighting, and the way we use it, I think it only fair to talk a little bit about the why and the wherefore of it.

What we are doing in lighting is a practical application of the psychological. We have studied the audience, or the people with whom we are doing business and whom we desire to entertain. We are merely applying that which we have found through hard work and study.

We are a peculiar nation. We are living very, very rapidly. We are a nation with a perpetual sandwich in our hand. In other words, we are a cafeteria nation. We live rapidly. We never quite get set. We can't do as they do across the water. We

*A paper presented before the New York Section of the Illuminating Engineering Society, January 11, 1923.

**Managing Director of the Capitol Theatre, New York City.

don't have two and a half or three hours for our dinner, and hour luncheons, and we don't stop in the afternoon to have tea. We are going all the time.

And what we have done, as culminated in the Capitol Theatre, is this: we have taken you and them out of this tremendous turmoil, we take you in our arms as it were, by the service which places you in a seat as quickly as we possibly can. Then we take your tired and frazzled nerves, and we try to calm them and bring them down to their normal level. We entertain you, and there isn't any factor more conductive to getting that result than the lighting.

We have in the Capitol a rather unique system of lighting. As I told you before, I know nothing of lighting, as you know it, and as the artist knows it, but what we have done is this:

We have organized an equipment—probably the finest lighting equipment in the world. We have so organized, amplified, and intensified it that we are able to use this phrase,—"We paint with light." Whatever we do is not mysterious. It isn't intricate. There is nothing that we do that no one else can not do. We use the same gelatin that you all use; only four colors. There is red,—the different grades of it. There is blue. There is amber and there is green. We very rarely ever use what is known as white light, that is, a naked light.

Now comes the rehearsal. My art director has conferred with me early in the week and we have arranged a certain number of units. For instance, this week we are doing a little scarf dance. We haven't any scenery, except one little bit of fabric, a drop which is painted in relief, as it were, with a suggestion of an arch, the shadow and a pool, and the rest is simply neutral. That's all the scenery we have in the entire bill this week. We don't believe in scenery. We create and paint our scenes with light.

Now it is our business to create a mood and to interpret the scarf-dancer. I am going to show you how we do it.

We start from the very back wall, which is a unit,—the back unit,—which you call psychic, those of you who are acquainted with that. We start there, taking our pattern from nature. We have a unit which is called Number eleven. I call for Number eleven in blue. I use a certain number of blue. The boys

through a course of training know exactly what I want, and I get it on my dimmer plate. It comes up slowly to where I want it, and then I say, "That's good." Then I work from Number twelve, which is a unit above it. I pour in a little green, and then from my side lamps and my strips, or whatever unit I want to use, I may pour in a little amplification, or a little reinforcement, in order to get that dim slightly hazy effect that I want, which is obtained by throwing light upon light, or by crossing rays and a certain amount of diffusion.

Now this is all done in the rear of this fabric ground—and from an ordinary nondescript piece of tapestry begins to loom up the shadow of the outline of the composition.

Then in front I begin to use diffusing light. On top of that, for instance, I may begin to sneak in a little bit of red and imagine that I am seeking the fringe of the setting sun behind me, just about to go down. That gives me red and yellow. I let my imagination play and begin to color the front of that drop to any proportion that I want. Then, to create a more realistic effect, I take a stereopticon and place it off and throw in a ray directly across just to give that little pool a little rippling,—enough to suggest that it is water—not obvious, not blatant, not cheap, but just enough so that it begins to simmer. Then in front of the whole thing we simply throw a couple of long pieces of chiffon that go into the wings or into the fly. There we have our background. Now that's for the small proscenium.

I have spoken to you about subtle effects, about appealing to the imagination. That is the true charm of all entertainment, appealing to your imagination—to make your imagination play. As you sit and watch motion pictures in your subconscious self you are supplying the color. You are supplying the words, the music, the sounds. You feel the emotions, according to your respective capacities.

The future of this kind of work will be in that one thing, to suggest so subtly—just to give you an outline and let you supply the balance. That is what we doing at the Capitol.

In the theatre of the future, the lighting is going to play a very important part. You are not going to see a single light. You will be transported from one mood to another simply by the

change and combination of color and lighting. There will be no decorative work or plastered ornamentation in this theatre. The building is going to be shaped somewhat like an egg, just a plain, neutral ceiling side. There isn't going to be any balcony —just a big group of chairs, and all around there will be light. There will be a wainscoting and certain units throughout the house are going to project rays to portions of that surface and they are going to be reflected again to you so that there will be an ideal form of lighting.

The stage equipment will be an absolute revolution in stage lighting. The advancement of the incandescent lamp, the advencement of projecting with the aid of reflectors, the advancement of the automatic machinery to control this, will absolutely revolutionize lighting as we know it to-day.

The old-fashioned border lights and the old-tashioned footlights will be gone. They will be superseded by tubular units, in which there will be a revolving cylinder, or two or three revolving cylinders, controlled by automatic machinery, and these cylinders will be composed of a very fine, highly sensitized prism —very luminous. This prism will pass over the object and will then be diffused down so that we will be able to control with one unit of lamps almost any shade or any combination of colors that we could possibly wish for.

Gelatin is a thing of the past. We are going to create and make our own colors, and we need them. Toward that end we are now experimenting with certain fluids mixed with liquid, which we pour into a receptacle and which we can color instantly to any grade of red, blue or pink. We can bring it down to absolutely pitch black and then take it away again to the most delicate hues of blue, and then plain—almost water-like. We get a little milky effect, a frost, that is perfectly delightful.

Now what I think we need in the near future more than anything else is better equipment to get better control. That is the thing that is essential in lighting. The rest is creative—the making of something that you can pour out to those to whom you wish to pour it, by light, and that is what we are trying to do at the Capitol—impressionistic lighting. We are not trying to do anything different. We don't intend to blaze any new paths. We are simply trying to express ourselves in light, in

color, to enhance, as it were, or to bring forth to you the mood that we are working on.

I spoke about the novelty effects. One novelty effect that we did last year that comes to me very readily was probably the greatest novelty that I did last year, an effect called, "The Song of India." It was an interpretation of Rimsky-Korsakoff's "Chanson Indoue." I interpreted it in the following way. I have been to India, and I pictured, as I saw it there, one of the little quays right outside of Calcutta, with a little knoll, and a little, drooping palm. I saw the rocky coast and I saw this young Indian prince standing there gazing out on to the waters. The waves were breaking over the rocks, and I saw these little sea-nymphs come out of the water and call mysteriously, calling him until he went, he knew not where, but he went. He went into the water and disappeared. Now here is how we accomplished that.

We used a plain white drop as our sky. We colored it a little blue, just so that it made a horizon. Then we gave it a little tinge of lighter blue. Then we crossed over a very fine ray of frost, just enough to create a sort of a fog, rather a mist. Then we put a roll in front and we covered this roll with a little bit of cheese-cloth, just so as to give me a surface to project on. Then I got a sea scene from a moving picture film, made a loop and put it in the machine in a way so that the same scene would keep coming around and around and you wouldn't see any flash of different scenes as you so often do in moving pictures. We didn't have time to take six or seven minutes of the surf breaking over, so we used this little loop in the machine and continued it around, projecting it right on top of that scene, matching off, if you please, the very edges of the scene itself. Then we cut the sky and matched that off, so that we projected it with a very high-powered lamp and a long focused lens in order to get all the intensity possible. Then we projected it on this little bit of cheese-cloth, this sort of hedge, and there we had surf breaking over the rocks all the time you saw it, and from behind this little hedge, girls simply danced and they danced as though they were in the water. They went up and down and the surf kept breaking all the time, and the effect was quite an illusion. Probably some of you saw it. And you see it wasn't so difficult

at all. Simply an idea which we were able to put across, because we had worked hard and studied our projection and knew the possibilities, and we weren't afraid to try.

I want to tell you that if I could paint to you what I see in the future of this work you would think I was a raving maniac. I stop painting pictures of the future, because I fear they will put me away some day and I don't want to be put away yet. And I see it just as clearly as I saw the Capitol fifteen years ago.

You are going to see pictures projected into space. You are going to see lighting effects that will take the breath right out of your body. You are going to be awed. You are going to "ah" yourself into a state of non-resistance. You are going to see orchestras of one hundred and fifty or two hundred and fifty men, and a new instrumentation of an entirely different form. You are going to see productions where there isn't going to be any stage at all, just a big sweep. You are going to see the scene which is to be portrayed brought out into the theatre itself and you are going to sit right in the middle of it, and you are going to be part of that performance, just as we are trying to make you a part of our performance to-day. We don't tell this to a great many people, but I am telling you. You come into the Capitol Theatre and are just as much a part of our entertainment as the actor performing. That's the psychology of it. I make you play with us, and when I can do that—that's all I want.

I made a prophecy in Boston that the lighting of the theatre of to-morrow would be controlled from one unit, the same as the piano. I don't mean by that that they are going to strike notes—the thing that they did in Paris, where every note meant a light—that is a lot of bunk, but I do believe in mood, I believe profoundly in that. How many times have you witnessed the finale of a big selection—they bring up a light and the combination of eye and ear is much greater. If you could see that same climax without the lights coming up and giving it the general boost, if you could see it alone and flat, why you would be amazed at the difference.

DISCUSSION

The papers by Messrs. Rothafel and Hartmann were discussed together. See page 426.

LIGHTING EFFECTS ON THE STAGE*

BY LOUIS HARTMANN**

SYNOPSIS: The author speaks of the value of lighting in the theatre and of the lack of uniform outfits in different theatres necessitating a complete electrical equipment for every play. He describes his method of lighting interior and exterior scenes of dramatic productions, calling attention to the difficulties encountered, such as the impossibility of obtaining pure color effects and the danger of over-illumination.

He uses reflex glass as a medium for softening light, on both reflectors and lenses. In some cases foot lights are dispensed with and overhead lighting alone is used.

The most desirable stage lighting is simple in construction and not radical in effect. The possibilities in the lighting of the drama are unlimited when combined with intelligence and imagination.

We all know that there are numerous possibilities in the field of lighting; but I am going to say a few words about the part of it that I know best, and love best,— the lighting of the drama.

My real experience began with David Belasco about twenty-two years ago; although I had been employed in theatres years previous to this time, it was not until I came to work for David Belasco that I awoke to the realization of what light means to the stage, how valuable it is, and how much it assists the drama. Volumes could be written on this subject, but they would only serve as the expression of an idea; as text books they would contain very little of value.

When we speak of light in the commercial field, it is generally treated as a slide rule proposition; it resolves itself into a thing of mathematics—of course there are some exceptions to this, but I mean in general. There are several well known systems which have proved successful, their application being a product of well worked out formulae. In theatre lighting we have no formula; it is replaced by a truism that can be expressed in one sentence: "Love your work." This seems easy enough as there is a certain fascination about it; but with a great many new comers the strain of long rehearsals and lack of sleep dampens the enthusiasm they felt at first.

*A paper presented before the New York Section of the Illuminating Engineering Society, January 11, 1923.

**Lighting Engineer, The David Belasco Productions, New York City.

Stage lighting cannot be treated as a subject by itself; it is but a component part of a structure and of itself has no value. But if the play and its accessories are well conceived, proper lighting is a matter of great importance as it practically creates the atmosphere for the scenes. To obtain the best results, the lights require intelligent handling and good electrical equipment. It is very essential to have smoothly working dimmers, and a sufficient number of them, so each lamp or unit of lamps may be controlled separately. This is the only way by which the proper balance of light can be maintained; without this balance, the lighting looks just what it is, a number of separate units throwing blotches of light, creating bad shadows and sharp contrasts. If the proper equipment is not available, it is better to light a scene with the foots and borders than to try to use paraphernalia which cannot be fully controlled. The lights when badly handled only tend to draw the attention of the audience and detract from the effect the player is trying to create. Everything on the stage can be done in so many different ways; and it is far better to do it in a simple manner than to spoil it by an elaborate attempt which cannot be carried out.

I have found it necessary to have a full electrical equipment for every play, as there is no uniformity of outfit in theatres. Even when all the equipment is carried, the effect is not always the same when a play is moved to another theatre. The change is generally caused by the foot lights. They are very necessary and essential when properly installed, but in most instances they are badly planned; some are not hooded at all, while others have one row under the hood (generally the colors), and the white row is either half way under the hood or entirely outside of it.

For dramatic productions no light from the foots should strike the proscenium—much less illuminate the proscenium; and when properly installed, the audience should not be aware of their existence. The light from the foots should be so directed that it does not strike the ceiling of the setting. For this purpose I have found reflectors very efficient. There are several types which serve this purpose, and by painting parts of the reflector black I have been able to place the light about where I wanted it. In most instances I have found the small round bulb 25-watt

lamp to give sufficient light for the foots when used in a scoopette reflector.

For a ceiling strip, I use the same reflector and lamp, fixed in a special strip. This may be tilted at any angle, takes up very little room, and does not throw the light on the ceiling. The ceiling gets all the illumination it requires from natural reflection. All scenes to be effective require light and shade. By using merely foots and ceiling strip, the scenes are flat, there being no contrast. Baby lenses have made it possible to get this contrast in interiors. This form of lighting was worked out in the Belasco Theatre and used for the first time in Mr. Warfield's play "The Music Master." One of the scenes where this was especially effective was where Von Barwig holds up the lighted lamp to see Helen's face. I'll never forget the many times Mr. Warfield lifted up that lamp during rehearsals while we struggled to bring up the babies at the right time.

For these baby lenses I found a concentrated filament lamp put on the market for use in small stereopticons for the home. It was rated at 50 candlepower. I built a housing for it, fitted it with a 5-inch x 9-inch focus lens, and to control it I used a small dimmer having fourteen steps. We called it a baby lens, and this name has stuck to it. There are thousands of them in use to-day. Of course their candlepower has been increased. We have them in hoods of different shapes using from a 1½-inch lens to a 5-inch lens and ranging from 50 watts to 1,000 watts. We set them behind the drapery and up and down the sides of the scene on special frames and brackets, each one controlled by a separate dimmer operated by men who are trained for weeks in handling them. On the front of the balcony we have reflectors in special housings, also on separate dimmers. In this way we get the light from all angles, and when it is balanced by proper dimmer regulation, almost any effect may be obtained with this outfit.

I have found reflex glass a very effective medium for softening the light. I use it on both reflectors and lenses. It is superior to frosted gelatin for this purpose. Mr. Belasco managed to get some very fine results with the old arc lenses. We used to soften the light with a slide having graduated thicknesses of mica, each piece cut V-shape with the edges tapered. Still the

lamps were cumbersome and could not be placed to the best advantage.

When the tungsten lamp was put on the market Mr. Belasco told me to keep after the lamp manufacturers to get something that would prove more effective for our purpose. The American Lamp Company turned out two lamps for us which were very valuable at the time. One was a 6-volt concentrated filament lamp with two filaments. The other was a 60-volt lamp in a G. 40 bulb rated at 200 candlepower. I placed four of these in a bunch light; they looked like the sun—in those days. The light had an excellent quality and the diffusion was good, the filament being long; in fact, the light was superior to the modern 1,000-watt lamp so far as diffusion is concerned. In those days the Ward Leonard Company made hundreds of special rheostats for us. All this entailed a greater cost than if we had used stock materials, especially in the lamps, as we had to carry a large supply or wait three to four weeks for them, which was out of the question. In the theatre you need things quickly.

In some of Mr. Belasco's plays we discarded the foot lights entirely. "Peter Grimm" was lighted from over-head by strips and babies. Nine men were rehearsed for two weeks and then it took six weeks on the road before the lighting was finally perfected. "Marie Odile" also was lighted without foots. The scene of this play was laid in a convent. The effect of the light was as though it came through a large Gothic opening over the door. Foots would have ruined the atmosphere of this scene.

Whatever Mr. Belasco has tried in this line has been for the purpose of obtaining atmosphere for the play. Nothing is done in haphazard fashion; everything is the outcome of a preconceived plan. The original idea is worked on and experimented with until the best result has been obtained. The results are not always satisfactory to him, but if they do not come up to his expectations, it is the fault of a condition that cannot be remedied. You cannot always have perfection in all things on the stage, as there are numerous obstacles which present themselves. In planning a production the first details are worked out from the models, which are made to a scale of one-half inch to the foot. The artist tries to make his scenes as effective as possible, and where there are several of these scenes in a production, the working

oom on the stage is very cramped. This is one of the reasons hy the lights can not always be placed where they will give the est effect. The only thing to do in a case of this kind is to ke the available space and experiment until you have obtained e best results you can get under the prevailing conditions. I ave seen Mr. Belasco cut out an entire scene and re-arrange the ay when the conditions for lighting proved too unsatisfactory. cenery is nothing but canvas and paint and appears as such hen badly lighted. The reason we spend so much time with e scenery and the lights is that we realize their imperfections, garding them as necessary evils. When they become so obusive as to detract from the play, we eliminate them.

The tendency to-day is to use too much light. The high wattage mp has brought about this condition. I can remember when gas as the means of illumination in theatres, and the effect of gas ght on the scenery as a whole was better and softer. It was imossible to over-illuminate a scene in those days. The contrasts ere worked out in the painting. To-day we depend upon the ght to accomplish this. In illuminating a stage in a large eatre it is not good to bring up the foot-lights so high that the pression on the player's face may be seen from the last row, feat you could not accomplish by day-light. It is a mistaken ea to think that an actor's face must always be in a bright light. all depends upon what he is doing. To work in semi-light is aid to the actor at times.

Another difficulty experienced to-day lies in the color values. is almost impossible to obtain pure color, either in the pigments sed on the scenery or in the gelatines used on the lamps. The olors used on the scenery are dull and lifeless. When a color ould be vibrant, it is instead flat and dirty looking. This is used to some extent by the fire-proofing solution, which conins ammonia, an alkali that is ruinous to certain colors. Coalt blue, an excellent medium for a sky, looks like a dirty white ash after it has been fire-proofed. In some instances the bric is fire-proofed before the paint is applied but the result about the same. The anilines used in the gelatine mediums lso are poor, and it is impossible to obtain a blue without a urple or green tinge. This is often the reason why the color alues are unsatisfactory. We have to take the best we can get

and make the most of it. I have tried to procure glass to take the place of gelatines, but could not find sufficient uniformity, especially in the blue. The light blue was effective, but the dark blue varied in shade even when all the pieces were cut from the same sheet. Colored glass is blown in large sheets and varies in thickness, which causes this difference.

For the lighting of exteriors I have found reflectors of twelve inches and over of great value when fitted with proper spill-rings; but they are harder to handle in some cases than lenses, the light leaving the reflector with such a wide spread that it is difficult at times to kill reflections. In some cases I have made the spill-rings very long, at other times I have put long flippers on the side which could be closed in. The conditions vary as to space so that one must continually experiment. Generally they can be overcome in one way or another. To light a scene where the lights remain stationary during an entire act is simple, when compared with an act that has several changes of light.

One of the most difficult changes is to reduce gradually the illumination of an interior scene in a manner to simulate the setting of the sun and the approach of twilight. To keep these graduations perfect requires a great deal of time and patience. The lights inside and out must be on certain steps of the dimmers at a certain time; and to get the same tempo they must always be on a given point when a particular line of the dialogue is spoken. This change would be easy if the man operating it could see it, but the set is boxed in and he is working on the side where he does not see. By putting the switch-board under the stage with a hood in the apron, the man can look through—but this has proved unsatisfactory for a number of reasons. It was tried in the Century and abandoned. The Metropolitan Opera House still has this system, but the same men are operating it to-day who operated it when it was first installed.

Imagination is the theory of the theatre. People do not come to the theatre to see reality. On the stage you must exaggerate to be convincing. The public comes to the theatre to be fooled, but there is a vast difference between fooling an audience and insulting its intelligence. Use your imagination, but be logical. In other words you must make the audience see things as you

vant them to see them, and if your imagination is great enough ou can convey any mood and make them feel it. Radical de-artures seldom succeed in the theatre, as the audience does not vant to do any guessing. If the things you are doing appear alse, you lose the attention of your public. A clever stage irector guards against this. If the dialogue drags he brings in omething to divert unconsciously their attention; a shift of light nay change the entire mood, creating a mental change,—in short play on the senses. You have watched a good magician. He as everything timed, nothing is left to chance. He draws your ttention to something, but all the time he is talking. After you eave the theatre you don't remember what he said, but you re-nember his tricks. Still, in most instances, it was the talking that nade the trick possible. In drama the process is the same—ex-ept that it is reversed. You remember the play but forget the rick. Big mechanical devices are generally easy to construct and he effects they create are valuable. It is the little fine touches hat are really difficult, and in the end make the greatest im-ression, although you are not aware of it.

I could take up your time by describing to you in detail the ifferent forms of apparatus now in use in the theatre, but you re familiar with lenses and parabolic mirrors. The housings or them depend upon the size of the lamp you wish to use, to ive them proper ventilation without having leaks of light, and o make them as compact as possible. The shapes may vary to uit different conditions. But it is the intelligence you display n handling them that really counts—something that can come o you only through experience.

Good apparatus should be simple, the simpler the better. The asier it is to handle the less time is consumed in getting results,— great factor during rehearsals when time means so much. In ig productions, scene and light rehearsals take an entire week, ometimes longer, the men working night and day. Even where he expense is of no consideration, the players become nervous hrough waiting, so anything that will save time is of the utmost mportance.

In placing the lighting equipment, it is well to have enough ap-aratus to be able to put it in every conceivable place where a ght could possibly be used,—having it wired and connected to

the switch-board. If it is not used it can be taken down, but if used the time saved is valuable.

As I have said, there are untold possibilities in the field of lighting; and not only in the theatre but everywhere that light is used. To realize this you have but to look at the number of stores where they make use of colored light in the windows, projected either by lenses or reflectors. This is an idea borrowed from the theatre. This is one of the reasons why I believe that what is done in the theatre can have a powerful influence, by stimulating the imagination, thus creating a sense of the idealistic and applying it to the commonplace.

DISCUSSION

WILLIAM HALL: I thank you, Ladies and Gentlemen, but I am absolutely unprepared. I am simply stepping forward to take some one else's place who has disappointed you.

I am very much pleased with two of the statements heard here this evening, one of them that even though we of the stage appear old-fashioned, they have to refer back to our old-fashioned methods to gain effects. Let me take you back to 1887 when I first started as a gas boy, at the old Niblo's Garden.

Can you imagine climbing out on the grooves (they shifted the scenes on and off stage in these) twenty feet from the stage level, with a pair of calcium light cylinders a little bigger than a fire extinguisher strapped to your back, a calcium light reflector fifteen inches in diameter fastened on your chest, holding a set of colors between your knees, and forty men changing the colors at the same time for the dance group pictures which occurred generally every sixteen bars of the music.

I have always claimed that the electric switchboard and dimmer equipment is only the evolution of the old gas table or switchboard, not a new creation. With the gas table of other days we accomplished the same results you obtain to-day—in a crude way, we will admit, but with wonderful results. I will state without fear of contradiction, that with the combination of the old gas lighting equipment and the calcium light apparatus, we have given productions that even in this era of advancement have never been equalled, that is so far as stage spectacular effect is concerned.

Understand this, we had producers in those days who were absolutely striving for accomplishment. Their hearts and souls were in the work, irrespective of the financial outcome. We had our Irving, our Davenport, our Henderson and Kiralfy, people who produced shows for the productive effect, not everything for the financial return. They went at things in a different way than they do to-day. Commercialism did not enter into it.

A few of my very pleasant experiences. As a gas boy in Niblo's Garden, to make dark changes the lights were turned down to a blue flame by a by-pass valve system; frequently the draft would blow out the flame during the change, to light a border light it would then be necessary to take a long pole, say thirty feet long, with an alcohol torch fastened on end and touch the gas tips. Perhaps the gas would have been turned full on, then you would see a flash of flame the entire length of the border, some fifty feet. (Laughter). But we did not have any fires. But my what a noise! Just like a flash light powder going off on a large scale. The audience get frightened? No, they got used to it I guess. (Laughter).

Recalling my traveling with Fanny Davenport through the country. That was in 1895. Electricity was just being introduced in the theatres then—we had with us what was called the Meyerhoffer lamp. The Universal Stage Lighting Company is the successor of that company and far advanced away beyond the Meyerhoffer period I am pleased to say. The Meyerhoffer device was of the hand feed type, to feed taking up the amount of carbon consumed it was necessary to place your hand generally up to a height above your head in an opening inside of the hood and turn the feed screw.

On this trip in the West, San Diego, California, was the place I think, looking for electricians as operators, I could not get anybody but a trolley car motorman (laughter); of course, he was an electrician. (Laughter). Understand the situation; Fanny Davenport was playing in one of Mr. Hartman's productions, the place had to be kept very quiet. As the operator (trolley motorman) would reach up to feed up on the carbon, his natural inclination was to stamp on the floor as if clanging his bell. (Laughter). Can you imagine the effect of this interruption

on Fanny Davenport? I came very near losing my position over the incident.

Along those lines and over such obstacles we advanced with electricity. Once for a choke coil for five hundred and fifty volts I used up an old bed spring taking the spiral springs and fastening them together, quite an accomplishment for those days and naturally I was proud of it, placed the coil in the cellar of the theatre with a switch on a post alongside of it. The arc from the slow break of the switch had me hesitating though about handling it; so rigged up a set of pull strings extending to a pocket on the stage floor and opened and closed the switch from that safe point. Got kind of careless though toward the end of the week and while proudly exhibiting the device to the power house electrician thoughtlessly placed my hand on those five hundred and fifty volts and was knocked clear across the cellar (Laughter). We had practical lessons in those days.

An interesting statement this evening was that they had natural phenomena in the theatre to-day and how naturally these results and effects were accomplished. Of course in this era the motion picture has cut out a lot of our effects. Mr. Rothafel described how he obtained a water ripple effect to illustrate a song with the motion picture machine. The first way we made water ripple effects was with a large metal barrel with holes or slots cut horizontally; into the inside of which we would place a couple of calcium light burners and revolve the barrel around the lights. By this same method of operation we had cloud effects painted on glass revolving in front of lens lamps.

Mr. Rothafel has told you of some very natural effects they obtain to-day. Well, I guess we had some natural ones in the old days too. With the Savage Grand Opera Company for Carmen the rocky pass scene in the third act the back drop had a waterfall painted on it for the full length ending in a sort of ravine. Behind the drop we had a projective water fall effect. Set in front was a runway for Don Jose's entrance on horseback. Well, as the horse made his entrance he would invariably stop to take a drink out of the waterfall. (Laughter).

In traveling through the country with a show I carried apparatus for a combination of gas and electricity. The devices would have a gas burner for the calcium or if electricity was

vailable, remove the gas burner and place the arc carbon burner n the same hood. So you see, we were quite resourceful in hose days. Admitting an advance in the lighting of the present day theatre, I would say that if you have any idea of going nto the field of stage illumination, I would recommend you gather ll the data possible on how we accomplished results in the old ays. For spectacular lighting, I have not up to the present ay and I have been associated with some of the largest producions ever staged in my capacity as department head with the New York Calcium Light Co., seen a production to equal any f the productions as given at the New York Theatre like "The Man in the Moon," "The King's Carnival" or "Million Dollars." The Hippodrome had some wonderful spectacles, but even they lo not compare with spectacles of the past.

Mr. Rothafel has described the wonderful new theatre he has in nind, with electric lamps set around like footlights surrounded vith glass prisms eliminating the coloring of lamps or sheet gelatines for color effect and how he would have a mechanical ystem to turn these colored prisms of glass in front of the lamps for desired color changes. As Mr. Rothafel extended you an invitation to visit him, I will also invite you to come any time to ny office and I will show these same colored glasses as used in he Eighties set around arc and gas burners on an individual revolving base with a string attached so we could turn any color we desired in front of the burner; once again illustrating my contention that you have to go some to show anything new in stage ighting to anyone of the gentlemen who are here to-night and associated with the stage as long as I have been. I still contend you are adapting a different method of doing something simpler than the way we did it. We of the stage do not wish to retard you in any way, we welcome you to show us something new, come over to our Company, talk over what you have in mind, we will show you how we did it and help you all we can. That is all I have to say. Thank you.

W. D'A. RYAN: I have been very greatly interested in the two excellent addresses delivered to-night. While I am not in a position from experience to discuss theatre lighting, I have had some experience in the use of color on a large scale.

Color is just as important in giving pleasure as music, whe properly handled. The first experience that I had in color wa possibly twenty-five years ago at Bass Point, Nahant. I trie out there, on artificial clouds created by specially-prepared shell for making smoke, the effect of color on the public, and wa greatly pleased to see what wonderful drawing power that had.

At the time of the Hudson-Fulton Centennial. you probabl recall some of the color effects used on the river, and the illumina tion of Niagara Falls in 1907, but the climax in color on a larg scale was at San Francisco in 1915 at the Panama-Pacific Inter national Exposition.

We had one color effect alone—spectacular—aside from th general color used, covering possibly nine million square feet o surface, a battery of searchlights of a combined beam candle power of a little over two billion, six hundred million,—visibl eighty or ninety miles away, as far as Sacramento. It is ad mitted by the Exposition officials that that color effect, the color ing of the Exposition, the light at night, and particularly th effect of this scintillator, did more than any other one thing t make that Exposition a financial success in the face of the war

There were forty-eight searchlights, manned in such a wa that they could control for various combinations of color, and ove three hundred specially prepared shells, and the effects were le up to a final climax in which five hundred shells were thrown int the air in one second, one half being four and a half inch. W had a locomotive, largest Pacific type, to generate steam fo certain effects, and the final was a climax of all the effects, and i never failed to impress the people.

Following the Exposition, the first case that I know of the use of color in a theatre, for the house proper, that is, distinguish-ing it from the effects used on the stage, was in Growman's Theatre in Los Angeles. They followed some of the effects similar to those used in the Exposition, where we brought out in very fine silhouette many of the decorative features of the building.

I have noted a number of instances since, but may say that in general they are too harsh. They go too much to strong color rather than tints and shades, and too much contrast and not par-

ticularly happy combinations. That is just a general statement. There are some theatres very beautifully treated, but I think the tendency in the window lighting also is to get too harsh effects in the combinations, and it is like anything developing new —it will start in crude and finally become refined.

Now, in conclusion, I would like to say that there is not anything more important to the public to-day than the art of colored lighting, and I believe that every effort should be put forth to study that art and develop it to a high degree of perfection within the coming years.

M. J. Levy: I was very much interested in what Mr. Rothafel said. I have known him for probably ten years. I remember when he first came here, when he went to the Strand Theatre and there tried to impress the owners with the idea of having colored lighting in the auditorium. As the theatre was pretty well finished by that time, we could not help him out. I had designed the electric lighting installation of this house as I have of three hundred other theatres throughout the country.

When Mr. Rothafel built the Rialto Theatre in New York he came to me and said, "Now I want something here that I can operate, the same as an artist plays on the piano," and he had drummed the architect full of his notions—full of three-color auditorium lighting. The architect did not quite grasp him and sent him to me, and we carried out the lighting of that theatre as best we could, with what the builder and the architect would give us. We had a great deal of help from them, but we had a great deal of trouble with the different artisans, plasterers and particularly with the painter. We could not get the painter to put on the color we wanted. In fact, I do not believe I have been able to get a painter to put on color so that we could really show the color values of our lamps. As a rule, they put on a lot of browns and a lot of gold, particularly in domes and around cornices, and we have a great deal of trouble, but Mr. Rothafel at that time worked very hard to get that theatre in such shape that he could bring out his color lighting scheme. That was the first theatre of that kind. That is a matter of about eight or nine years ago.

Then Mr. Rothafel brought out the Rivoli Theatre, where that style of lighting was again used, and now in the Capitol Theatre.

A great many theatres have since been equipped with that kind of lighting, but I have found that in most places it is not properly used. A man like Mr. Rothafel with his artistic sense would use it properly. He has an idea of values. He does not smear it on, but I have found in a great many other theatres that the lighting effects are left to a stage electrician. Now there are a great many highly intelligent stage electricians, but the average man who gets into a house of that kind has not the necessary intelligence to follow the music, or follow the stage productions with the lights. It takes a man of a higher calibre, as is proven by the fact that a man like Mr. Rothafel directs that feature in his own theatre.

There is a statement of Mr. Hartman that is very much like the statements that I have made time and time again, on the subject of stage lighting. One great trouble with the stage has been that when the nitrogen lamp was introduced it was in the thousand watt unit. It is a pity that the one hundred watt, or even the fifty watt, had not been perfected long before the thousand watt, because the thousand watt unit, with all its glare, was used by the stage electricians because of its peculiar white effect, and as a consequence, stages are now crowded with thousand watt units, which give you simply glare. Stage illusion is entirely out of the question.

I know of one instance where, after we had given a theatre a very good equipment, the stage electrician came along and he said, "Do not want anything like that. I am going to put thousand watt units all over the place." He did, and on the opening night his back drop was unquestionably a back drop. It was not a scene. You could see every paint mark on that back drop. Where you expected to find a castle on a hill, with a road running up to the castle, you saw absolutely nothing but a flat piece of painting, and I think that the high intensive units should be used with much more skill and care than at present. It would be better if they were not used at all. Smaller units that diffuse the light would make the stage illusion complete. A great many stage managers and stage electricians forget that what you see on the stage is, as Mr. Hartman says, intended to fool the public. It

is intended to create an atmosphere in which the public sees something that is not actual. And so the lighting unit should be kept down. There should not be quite so much of the glare. There should not be quite so much of the intent to create daylight on the stage, because it cannot be done, without overstepping the mark. You cannot get artificial daylight, as daylight appears to you in the day time. It is a rather difficult proposition, and the best you can do is to create an illusion that will make you think it is daylight.

DAYLIGHT ILLUMINATION ON HORIZONTAL, VERTICAL AND SLOPING SURFACES*

REPORT OF THE COMMITTEE ON SKY BRIGHTNESS,

H. H. KIMBALL, *Chairman*

SYNOPSIS: The report summarizes sky-brightness and daylight-illumination measurements made during the year ending April 6, 1922. For ten months the measurements were made in a suburb of Washington that is comparatively free from city smoke. During the other two months, one in summer and one in winter, the measurements were made in the smoky atmosphere of the city of Chicago.

The measurements were made as nearly as possible with the sun at altitudes above the horizon of 0°, 20°, 40°, 60°, and 70°. From the sky-brightness measurements the resulting illumination on vertical surfaces differently oriented with respect to the sun, and on surfaces sloping at different angles and in different directions, has been computed. These computed values have been utilized, in connection with daylight-illumination measurements, to construct charts showing for latitude 42° north, illumination intensities for each hour of each day of the year as follows:

(1) On a vertical and on a horizontal surface, from a cloudy sky.

(2) On a horizontal surface and on vertical surfaces facing the eight principal points of the compass, from a clear sky.

(3) On a horizontal surface and on vertical surfaces facing the eight principal points of the compass, from the sun and clear sky combined.

The illumination on sloping surfaces from skylight and from solar and skylight combined has been summarized in tables.

The application of these data to the lighting of working space in a building through saw-tooth roof construction is show. It is pointed out that with a clear sky the larger proportion of the illumination should result from the reflection of light from the outside roof surface through the window opening, rather than by the direct transmission of skylight through the window.

With a cloudy sky the illumination on a horizontal surface is considerably more than twice that on a vertical surface, due to the fact that the region of maximum brightness is in or near the zenith.

With high sun, as at midday in summer, the illumination from a cloudy sky averages higher than the illumination from a clear sky, except on a vertical surface facing the sun. This is not the case with low sun.

The maximum illumination from a clear sky on vertical surfaces is a little in excess of 1,400 foot-candles, and occurs on surfaces facing the sun from early June to early September, between the hours of 8.30 A. M., and 3:30 P. M.

The minimum illumination from skylight is on a vertical surface facing away from the sun. At Chicago in the smoky Loop District the illumination from a cloudless sky on such a surface averages about two-thirds the illumination at Washington on a similar surface from a clear sky.

*A report presented at the annual convention of the Illuminating Engineering Society, Swampscott, Mass., September 28, 1922; later revised and extended.

The total (solar + sky) illumination generally increases on surfaces sloping toward the south until the angle of slope reaches 20°, except with low sun during the summer months. The maximum is about 11,000 foot-candles at noon in midsummer.

At Washington the illumination from a clear sky on both horizontal and vertical surfaces varies between 150 and 60 per cent of the average values; from a cloudy sky, between 200 and 30 per cent; from a sky partly covered with white clouds, on a horizontal surface three to four times, and on a vertical surface two to three times that from a clear sky; with rain falling, about half that from a cloudy sky.

SKY-BRIGHTNESS AND DAYLIGHT-ILLUMINATION MEASUREMENTS

In a report of this committee[1] presented at the Rochester meeting in September, 1921, the program of sky-brightness measurements was outlined, and some preliminary results were given. The program of a full year of sky-brightness measurements was completed on April 6, 1922. During four weeks ending with August 13, 1921, and a second four weeks ending with February 2, 1922, the measurements were made in the city of Chicago. During the remainder of the year they were made in a suburb of the city of Washington that is practically free from city smoke.

As was explained in the previous report, at Washington the photometer was mounted on a stand inside a small shelter that was painted white on the outside and flat black on the inside. The upper edge of the sides of the house is on a level with the center of the elbow tube of the photometer when the latter is horizontal. This exposure permits measurements of the illumination from skylight on both horizontal and vertical surfaces. With a clear sky, however, illumination measurements on vertical surfaces have been confined to surfaces facing in azimuth 0° and 45° from the sun, as at greater azimuths the blackened inside walls of the shelter reflect too much sunlight to the photometer.

It may be well to recall to mind some details of the sky-brightness measurements. Figure 1 is a stereographic projection of the half of the sky on either side of the sun's vertical. The sun's position is indicated by the letter X. The horizontal straight line represents the horizon, and above it are lines of equal altitude 10° apart. Extending from the zenith to the horizon are azimuth circles also 10° apart.

[1] TRANSACTIONS, Illum. Eng. Soc., Oct., 1921. Vol. XVI. pp. 255-275. *Mo. Weather Rev.*, Sept., 1921, 49, pp. 481-488.

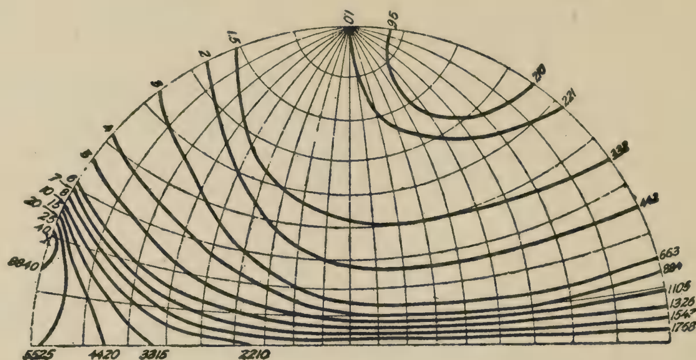


Fig. 1.—Sky brightness in millilamberts. Sun's position indicated by X. Washington, D. C., cloudless sky, ground covered with snow.

A complete series of sky-brightness measurements consists of three photometric readings on each of the points at 2°, 15°, 30°, 45°, 60°, 75°, and 90° above the horizon, and on azimuth circles 0°, 45°, 90°, 135°, and 180° from the sun, covering half the sky only. Unless the sky is cloudy the point that falls nearest the sun on azimuth circle 0° is usually too bright to measure with the screens at our disposal. There are therefore 102 photometric readings in each series. In addition, with a clear sky the intensity of the total illumination from the sun and sky is measured on a horizontal surface, and on a surface normal to the direct solar rays, and the illumination from skylight alone is measured on these two surfaces and also on vertical surfaces facing 0° and 45° in azimuth from the sun. If the sky is cloudy the illumination is measured on a horizontal surface, and on vertical surfaces facing 0°, 45°, 90°, 135°, and 180° in azimuth from the sun. There are therefore eighteen photometric readings (six sets of three readings each) in each series of illumination measurements. It is usually a matter of chance whether the readings are on azimuth circles to the right or to the left of the sun. Unless there is inequality in the cloud or haze distribution, or in the character of the earth's surface on the two sides of the sun's vertical, the sky brightness on the two sides should be symmetrical.

TABLE I.—NUMBER OF SERIES OF SKY-BRIGHTNESS MEASUREMENTS
WASHINGTON, D. C.

Solar altitude	0°	20°	40°	60°	70°	Total
Clear sky	9	62	122	23	11	227
Thin clouds	2	34	36	16	......	88
Partly cloudy sky	1	21	57	24	17	120
Cloudy sky	6	30	26	21	4	87
Rain or snow	......	3	6	8	......	17
Total	18	150	247	92	32	539

CHICAGO, ILL., FEDERAL BUILDING

Solar altitude	0°	20°	26°	40°	60°	Total
Clear sky	6	13	3	8	3	33
Thin clouds	......	8	5	2	6	21
Partly cloudy sky	5	9	......	7	9	30
Cloudy sky	4	6	3	1	1	15
Total	15	36	11	18	19	99

UNIVERSITY OF CHICAGO

Solar altitude	0°	20°	29°	40°	60°	Total
Clear sky	2	11	3	9	10	35
Thin clouds	.....	9	5	2	2	18
Partly cloudy sky	6	4	......	5	6	21
Cloudy sky	2	7	2	1	1	13
Total	10	31	10	17	19	87

The attempt is made to obtain complete series of sky-brightness and illumination measurements when the sun is 0°, 20°, 40°, 60°, and 70° above the horizon. On account of the length of the day the readings at 0° and 20° solar altitude are generally omitted in midsummer, and in winter the sun does not reach an altitude much in excess of 40°. In fact, at the Federal Building, Chicago, in January, the average altitude of the sun at the time of making the noon readings was 26°, and at the University of Chicago, at the end of January and early in February it was 29°. When rain was falling, only sky-brightness measurements up to an altitude of 60° could be made by pointing the photometer out of a window.

Table I gives the number of series of sky-brightness measurements obtained at Washington and Chicago with the sun at the altitudes indicated and with the different types of sky. In all

TABLE II.—AVERAGES OF SKY-BRIGHTNESS MEASUREMENES EXPRESSED IN TERMS OF ZENITH BRIGHTNESS. WASHINGTON, D. C.

Solar altitude	Point in sky where brightness was measured								Zenith brightness
	Azimuth from sun	Altitude							
		2°	15°	30°	45°	60°	75°	90°	mL.
	CLEAR SKY, WINTER								
0°	0	12.66	9.61	4.33	2.40	1.44	1.15	1.00	27.1
	45	4.40	4.76	2.83	1.98	1.36	1.15		
	90	2.43	2.76	2.08	1.47	1.20	1.10		
	135	2.99	3.43	2.41	1.58	1.17	1.03		
	180	3.83	4.20	2.74	1.77	1.25	1.08		
20°	0	23.52	......	9.78	4.27	2.26	1.42	1.00	281
	45	8.91	5.54	3.76	2.57	1.75	1.27		
	90	3.95	2.60	1.69	1.30	1.10	1.06		
	135	3.92	2.34	1.42	1.01	0.87	0.88		
	180	4.38	2.55	1.42	0.99	0.81	0.79		
40°	0	8.29	6.81	9.44	......	2.72	1.53	1.00	544
	45	4.56	3.45	2.77	2.21	1.76	1.36		
	90	2.62	1.66	1.12	1.00	0.89	0.95		
	135	2.51	1.33	0.82	0.68	0.66	0.75		
	180	2.76	1.44	0.81	0.60	0.58	0.69		
	CLEAR SKY, SUMMER								
20°	0	21.10	......	10.85	4.06	2.34	1.40	1.00	400
	45	7.72	5.90	3.91	2.74	1.94	1.31		
	90	3.42	2.81	1.78	1.35	1.07	1.14		
	135	2.48	1.86	1.23	0.83	0.72	0.82		
	180	2.85	2.13	1.19	0.85	0.74	0.76		
40°	0	7.35	6.19	8.43	......	2.75	1.58	1.00	803
	45	4.15	3.13	2.69	2.45	1.88	1.42		
	90	2.13	1.41	1.13	0.97	0.99	1.04		
	135	1.74	1.13	0.74	0.60	0.62	0.74		
	180	1.83	1.11	0.68	0.54	0.53	0.68		
60°	0	2.08	1.74	1.84	2.51	......	1.65	1.00	1,650
	45	1.74	1.53	1.30	1.53	1.67	1.41		
	90	1.16	0.88	0.72	0.74	0.88	0.99		
	135	0.95	0.61	0.47	0.50	0.58	0.75		
	180	1.00	0.64	0.47	0.50	0.54	0.72		
70°	0	1.45	1.29	1.13	1.60	3.30	......	1.00	2,300
	45	1.25	0.90	0.89	1.07	1.33	1.53		
	90	0.77	0.65	0.56	0.54	0.62	0.89		
	135	0.62	0.42	0.37	0.38	0.44	0.66		
	180	0.58	0.39	0.31	0.31	0.41	0.61		
	CLOUDY SKY, WINTER								
20°	0	0.39	0.59	0.80	0.93	1.03	1.04	1.00	989
	45	0.40	0.55	0.67	0.84	0.97	0.97		
	90	0.31	0.56	0.68	0.81	0.90	0.92	Max.=2,211	
	135	0.31	0.49	0.66	0.80	0.86	0.94		
	180	0.32	0.54	0.67	0.83	0.94	0.98	Min.=245	

here are about 55,000 photometric readings of sky brightness nd 9,000 photometric readings of illumination intensity at Washngton and 19,000 and 2,200, respectively, at Chicago.

In Tables II and III are summarized the sky-brightness measrements made at Washington and Chicago, respectively, during

TABLE III.—AVERAGE OF SKY-BRIGHTNESS MEASUREMENTS EXPRESSED IN TERMS OF ZENITH BRIGHTNESS. CHICAGO, ILL.

Place	Solar altitude	Point in sky where brightness was measured. Azimuth from sun	Altitude 2°	15°	30°	45°	60°	75°	90°	Zenith brightness mL.
			CLEAR SKY, WINTER.							
University	0°	0	9.80	8.04	3.67	2.03	1.38	1.08	1.00	19.4
		45	3.04	4.06	2.14	1.50	1.13	0.87		
		90	1.03	2.36	1.79	1.46	1.29	1.07		
		135	1.31	2.46	1.84	1.47	1.18	0.78		
		180	0.80	2.84	3.34	1.64	1.22	0.96		
Federal Building	0°	0	1.80	4.41	4.00	1.21	1.48	1.13	1.00	19.7
		45	0.85	2.11	2.04	1.54	1.36	1.10		
		90	0.80	1.29	1.27	1.24	1.03	0.99		
		135	0.88	1.88	1.00	1.43	1.05	1.08		
		180	1.11	2.12	1.85	1.66	1.25	1.09		
University	20°	0	16.38	. . .	9.18	4.25	2.21	1.22	1.00	345
		45	6.38	5.00	3.59	2.58	1.93	1.33		
		90	2.51	2.22	1.59	1.30	1.40	1.05		
		135	2.06	1.50	1.25	0.98	0.95	0.85		
		180	2.03	1.75	1.14	0.89	0.72	0.77		
Federal Building	20°	0	13.56	. . .	9.86	4.37	2.34	1.55	1.00	340
		45	5.30	4.87	3.37	2.59	1.96	1.16		
		90	1.98	1.93	1.70	1.35	1.31	1.00		
		135	1.24	1.27	1.01	0.75	0.66	0 72		
		180	1.32	1.45	1.08	0.79	0.72	0.82		
University	29°	0	13.65	18.80	. . .	3.72	2.61	1.37	1.00	433
		45	5.32	4.11	3.50	2.59	1.92	1.32		
		90	2.59	1.96	1.49	1.07	1.02	1.03		
		135	1.89	1.65	1.01	0.82	0.71	0.78		
		180	2.13	1.78	1.05	0.82	0.77	0.71		
Federal Building	26°	0	7.81	15.73	12.14	4.96	2.44	1.46	1.00	511
		45	3.84	4.12	4.02	2.85	2.04	0.94		
		90	0.95	1.20	1.39	0.93	0.79	1.00		
		135	0.73	0.72	0.73	0.73	0.73	0.89		
		180	0.65	0.80	0.70	0.58	0.63	0.75		
			CLOUDY SKY, WINTER.							
University	20°	0	0.29	0.52	0.86	1.06	1.07	1.08	1.00	614
		45	0.30	0.47	0.73	0.89	0.96	0.99		
		90	0.29	0.41	0.63	0.86	0.91	0.97	Max.=1,074	
		135	0.30	0.42	0.58	0.71	0.86	0.88		
		180	0.25	0.37	0.56	0.73	0.94	0.91	Min.=84	
Federal Building	20°	0	0.38	0.56	0.83	1.02	1.23	1.30	1.00	500
		45	0.33	0.61	0.56	0.78	0.93	1.10		
		90	0.42	0.64	0.74	0.92	1.09	1.10	Max.=1.034	
		135	0.34	0.43	0.60	0.98	1.13	1.08		
		180	0.33	0.56	0.80	0.84	0.70	0.93	Min.=132	

TABLE III. (CONTINUED)—AVERAGE OF SKY-BRIGHTNESS MEASUREMENTS EXPRESSED IN TERMS OF ZENITH BRIGHTNESS
CHICAGO, ILL.

Place	Solar altitude	Point in sky where brightness was measured								Zenith brightness
		Azimuth from sun	Altitude							
			2°	15°	30°	45°	60°	75°	90°	mL.
		CLEAR SKY, SUMMER								
University	8°	0	12.29	. . .	5.64	2.37	1.18	1.19	1.00	231
		45	5.46	5.09	2.65	1.83	1.17	0.90		
		90	3.43	2.37	1.35	1.07	0.95	0.76		
		135	2.62	2.18	1.36	0.96	0.72	0.84		
		180	2.73	2.69	1.64	0.91	0.79	0.86		
Do	20°	0	14.35	. . .	11.44	5.07	2.71	1.62	1.00	528
		45	5.91	5.04	3.88	2.62	1.86	1.32		
		90	2.77	2.26	1.61	1.25	1.09	1.04		
		135	1.69	1.60	1.04	0.73	0.68	0.72		
		180	1.58	1.78	1.04	0.71	0.64	0.70		
Federal Building . .	20°	0	15.08	13.73	13.58	6.19	2.79	2.20	1.00	419
		45	4.76	4.81	4.54	3.27	1.97	1.37		
		90	1.65	1.56	1.32	1.06	0.91	0.90		
		135	1.50	1.51	0.91	0.73	0.71	0.80		
		180	1.20	1.13	0.76	0.54	0.55	0.59		
University	40°	0	6.29	5.67	7.28	. . .	2.66	1.63	1.00	810
		45	3.72	3.07	2.70	2.57	2.16	1.49		
		90	1.68	1.41	1.15	1.09	0.96	0.98		
		135	1.73	1.05	0.77	0.73	0.72	0.83		
		180	1.26	0.97	0.61	0.48	0.50	0.62		
Federal Building . .	40°	0	4.50	5.56	6.35	. . .	3.23	1.76	1.00	900
		45	1.51	3.09	3.38	2.69	2.17	1.37		
		90	1.16	1.19	0.99	. . .	0.95	. . .		
		135	0.67	0.57	0.49	0.43	0.49	0.70		
		180	0.97	0.78	0.51	0.41	0.47	0.68		
University	60°	0	1.75	1.88	2.06	2.44	. . .	1.67	1.00	1920
		45	1.32	1.23	1.25	1.38	1.52	1.30		
		90	0.84	0.72	0.64	0.82	0.88	0.88		
		135	0.80	0.69	0.52	0.52	0.63	0.82		
		180	0.65	0.55	0.45	0.50	0.50	0.66		
Federal Building . .	60°	0	1.63	1.88	2.19	3.24	. . .	1.83	1.00	1360
		45	1.36	1.33	1.11	1.54	1.36	1.40		
		90	0.94	0.67	0.61	0.58	0.72	1.09		
		135	0.96	0.69	0.56	. . .	0.63	. . .		
		180	1.00	0.63	0.39	0.38	0.43	0.60		

summer and winter months with a cloudless sky, and during winter months with the sun 20° above the horizon and the sky covered with clouds. It will be noted from Table I that at Chicago most of the sky-brightness measurements with a cloudy sky were obtained when the sun was at an altitude of 20°.

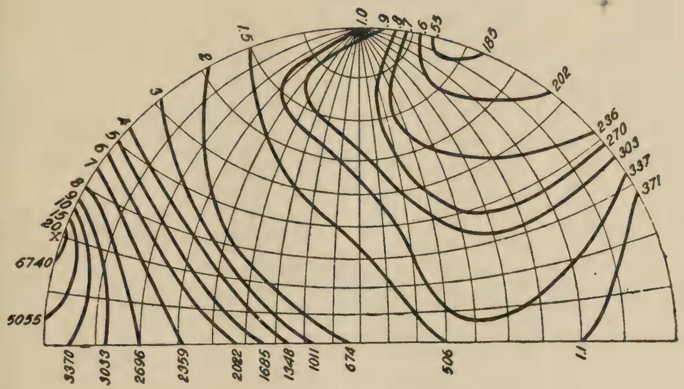


Fig. 2.—Sky brightness in millilamberts. Sun's position indicated by X. Federal uilding, Chicago, Ill., cloudless sky with dense smoke.

Referring again to Figure 1, the irregularly curved lines are nes of equal brightness that have been drawn to represent the rightness of the sky at Washington on the morning of February 7, 1922, with the sun at an altitude of 20°, and the ground overed with newly fallen crusted snow. The figures on the left bove the sun represent the brightness of the sky with reference the zenith brightness; the figures on the right and at the bottom f the figure, the brightness of the sky in millilamberts. The sky 0° from the sun and in his vertical was a deep blue and unusually ark. Near the horizon it was unusually bright on account of the eflection of light to the atmosphere from the snow surface, and specially beyond 90° in azimuth from the sun.

Figure 2 shows the brightness of the sky as measured from the op of the dome on the Federal Building, Chicago, Ill., on the orning of January 16, 1922, with no clouds in the sky, but heavy moke in the lower atmosphere. The sun was at altitude 20°, nd the ground was covered with snow, as was the case at Washngton on February 17, but the snow was not clean. Compared ith Figure 1, Figure 2 gives a brighter zenith, a point of miniium that is less bright, and a horizon beyond azimuth 90° from he sun only about one-fourth as bright.

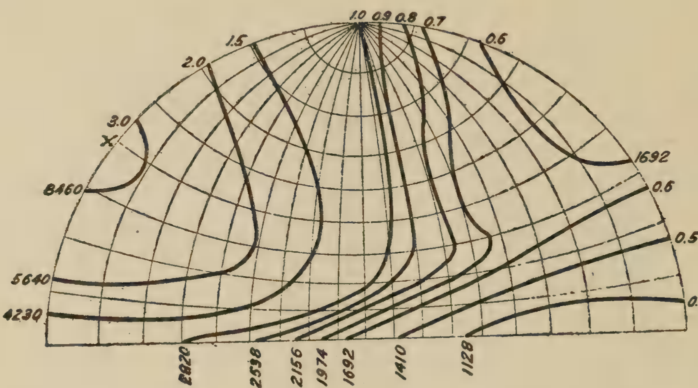


Fig. 3.—Sky brightness in millilamberts. Sun's position indicated by X. Washington, D. C., sky covered with dense haze.

Figure 3 represents the sky brightness at Washington on the morning of July 5, 1921, with the sky covered with dense haze but without clouds, and the sun 40° above the horizon. The sky is much brighter than a clear blue sky, except near the horizon opposite the sun.

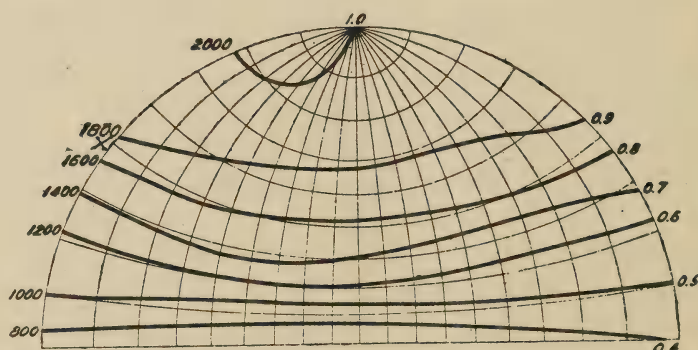


Fig. 4.—Sky brightness in millilamberts. Sun's position indicated by X. Washington, D. C., sky covered with dense clouds.

Figure 4 represents the mean of all the sky-brightness measurements at Washington with the sun 40° above the horizon, and the clouds so dense that neither blue sky nor the sun could be seen. The brightest point is near the zenith, and there is little

ariation in brightness with azimuth. The zenith and in general ie sky opposite the sun is brighter when covered with clouds ian when clear, but near the horizon and in the vicinity of the in the clear sky is much the brighter. Thin clouds, and clouds iat partly cover the sky, increase its brightness much the same s does haze.

ILLUMINATION FROM SKYLIGHT ON HORIZONTAL AND VERTICAL SURFACES

During the past year the energies of the committee, aside from ie observational work, have been directed principally to computing from the clear-sky-brightness measurements, as summared in Tables II and III, the resulting illumination on vertical irfaces facing in azimuth 70°, 90°, 135°, and 180° from the sun. he process is a simple one. As explained in the 1921 report,[3]

TABLE IV.—ILLUMINATION FROM SKYLIGHT, WASHINGTON, D. C.

Solar altitude	On horizontal surface	On vertical surface							
		Azimuth between normal to surface and sun's azimuth						Mean	Zenith brightness
		0°	45°	70°	90°	135°	180°		
	Foot-candles								mL.
CLOUDY SKY									
0°.	15.2	5.6	5.8	. . . .	6.4	6.7	7.1	6.3	15.8
20.2°. . . .	726	298	280	. . . .	273	273	272	279	989
41.0°. . . .	1,505	614	608	. . . .	615	622	606	613	2,000
51.4°. . . .	2,150	881	941	. . . .	977	932	929	932	3,600
71.4°. . . .	2,950	1,142	1,103	. . . .	1,118	1,122	1,203	1,138	4,840
CLEAR SKY, SUMMER									
20°	840	1,252	1.028	803	526	316	293	. . . .	400
40°	1,340	1,454	1,325	932	686	417	358	. . . .	803
60°	1,600	1,420	1,255	923	751	559	486	. . . .	1,650
70°	1,600	1,291	1,074	903	754	542	475	. . . .	2,300
CLEAR SKY, WINTER									
0°	67.8	64.6	63.7	. .	30.6	30.2	31.5	. . . .	27.1
20°	683	1,042	873	562	393	265	257	. . . .	281
40°	977	1,121	936	690	505	325	295	. . .	544

[3] TRANS., Illum. Eng. Soc., Vol. XVI, p. 267; *Mo. Weather Rev.*, Sept., 1921, 49, p. 485

the sky is divided into zones of equal angular width about a point on the horizon 90° in azimuth from the illuminated surface, and the horizontal component of the illumination from each zone is determined. The sum of the illumination from all the zones gives the total skylight illumination on the vertical surface.

Table IV summarizes the results of these computations from Washington measurements, and also the illumination measurements, for both clear and cloudy skies. The cloudy-sky measurements have been confined to skies with so dense a cloud layer that the position of the sun could not be seen. No seasonal variation in the illumination intensity is apparent. With clear skies the computations have been made for both midsummer (June to August) and midwinter (December to February) conditions.

These data have been plotted on Figure 5 (summer conditions) and Figure 6 (winter conditions) with the solar altitude as abscissas and illumination intensities as ordinates. By interpolating between the curves it is possible to determine the illumination intensity for both summer and winter conditions on a vertical surface facing at any desired azimuth from the sun, and with the sun at any desired altitude. For spring and fall months a straight-line interpolation has been made between winter and summer values.

Measurements with the sun on the horizon were made during the winter months only, and these measurements have been used for summer as well. With the sun at altitudes 20° and 40° it will be noted that the zenith brightness in winter is approximately 70 per cent of the corresponding brightness in summer. The percentage of winter to summer illumination is somewhat greater than this, since the brightness of the sky near the horizon in terms of the zenith brightness is greater in winter than in summer.

In the *Monthly Weather Review* for November, 1919, **47**, pp. 770-771, are given the altitude and azimuth of the sun for the 21st day of each month and for even-hour angles of the sun from the meridian, for latitudes 30°, 36°, 42°, and 48° north. Using the azimuths and altitudes for latitude 42° N., in connection with

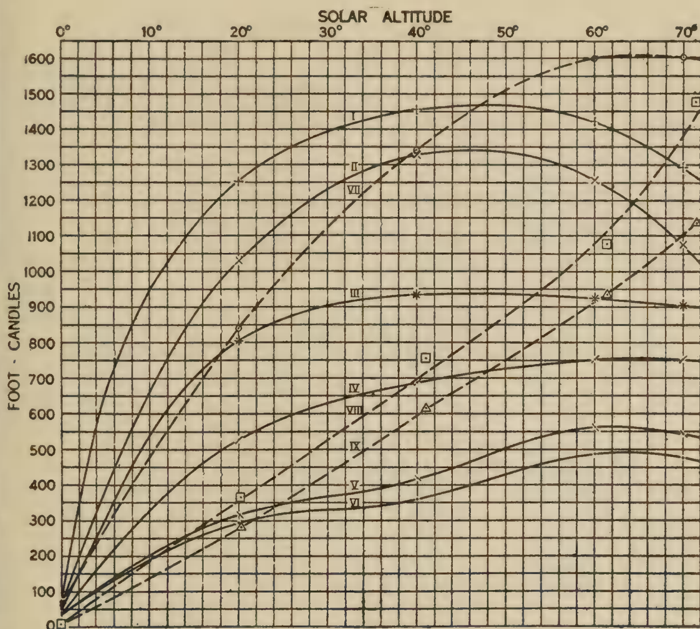


Fig. 5.—Curves of summer skylight illumination intensity on different surfaces.
Curve I. Clear sky. Vertical surface facing 0° in azimuth from sun.
Curve II. Clear sky. Vertical surface facing 45° in azimuth from sun.
Curve III. Clear sky. Vertical surface facing 70° in azimuth from sun.
Curve IV. Clear sky. Vertical surface facing 90° in azimuth from sun.
Curve V. Clear sky. Vertical surface facing 135° in azimuth from sun.
Curve VI. Clear sky. Vertical surface facing 180° in azimuth from sun.
Curve VII. Clear sky. Horizontal surface.
Curve VIII. Cloudy sky. Horizontal surface. (Note: Double the intensity scale).
Curve IX. Cloudy sky. Vertical surface.

the illumination intensity curves of Figures 5 and 6, Figures 7 to 18 have been drawn. Latitude 42° N. was selected because many important industrial districts are near this latitude, and also because measurements made at Washington, latitude 38° 56′ N., and Chicago, Ill., latitude 41° 53′ N., represent fairly well the sky brightness at this latitude east of the Mississippi River. Farther west the clear sky is generally a deeper blue and not so bright. Probably clear skies average brighter in low than in high latitudes, especially in winter. This conclusion is supported by Little's measurements made near Key

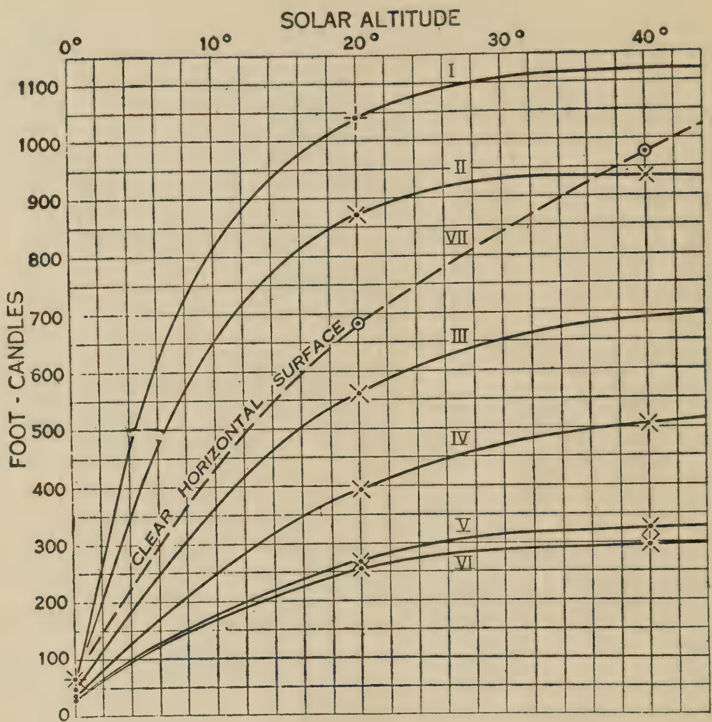


Fig. 6.—Curves of winter skylight illumination intensity on different surfaces.
Curve I. Clear sky. Vertical surface facing 0° in azimuth from sun.
Curve II. Clear sky. Vertical surface facing 45° in azimuth from sun.
Curve III. Clear sky. Vertical surface facing 70° in azimuth from sun.
Curve IV. Clear sky. Vertical surface facing 90° in azimuth from sun.
Curve V. Clear sky. Vertical surface facing 135° in azimuth from sun.
Curve VI. Clear sky. Vertical surface facing 180° in azimuth from sun.
Curve VII. Clear sky. Horizontal surface.

West, Fla., in February, 1918, which give for the zenith sky brightness with the sun at altitudes averaging 22.8°, 42°, and 53°, 390, 780, and 1,150 millilamberts, respectively; while measusements made by him from a ship off Long Island, N. Y., in October, 1917, give for the sky brightness with solar altitudes averaging 20.8°, and 41.2°, 296 and 495 millilamberts, respectively. The latter are somewhat lower readings than those obtained at Washington in winter with similar solar altitudes, while the Key West measurements are considerably higher.

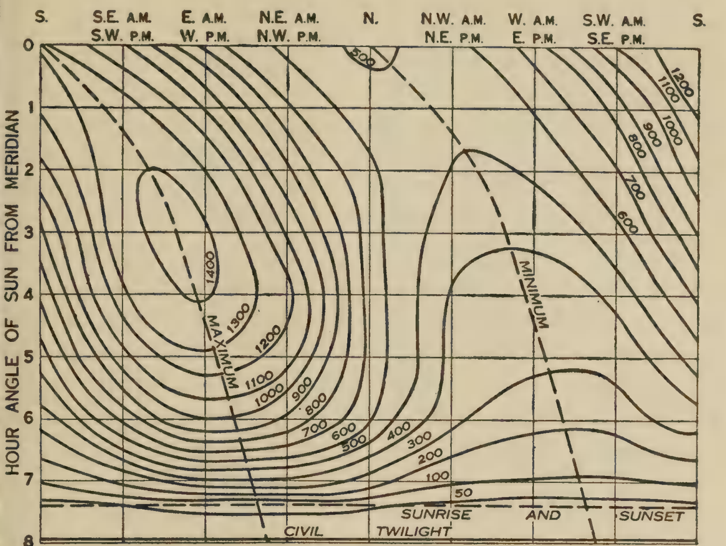


Fig. 7.—Variations in skylight illumination on vertical surfaces differently iented at latitude 42° north on July 21. Cloudless sky. Foot-candles.

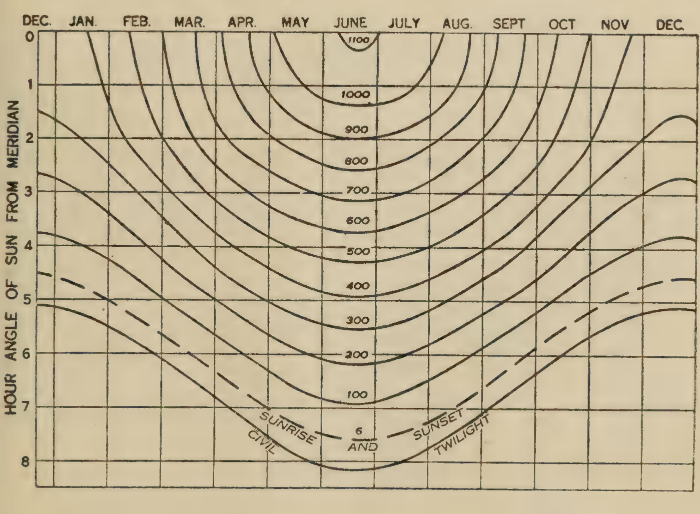


Fig. 8.—Illumination from a cloudy sky on a vertical surface at latitude 42° orth. Foot-candles.

Figure 7 shows the variations with the hour of the day in skylight illumination on vertical surfaces, such as the walls of buildings, differently oriented, on July 21, at latitude 42° N. with a clear sky. The maximum illumination is, of course, on a vertical surface facing the sun. It faces about east-northeast at sunrise, east at about 7:30 A. M., south at noon, west at about 4:30 P. M., and about west-northwest at sunset. The minimum illumination is on a vertical surface facing 180° in azimuth from the sun, or about west-southwest at sunrise, west at about 7:30 A. M., north at noon, east at about 4:30 P. M., and about east-southeast at sunset. Taking into consideration the hours between 7 A. M. and 5 P. M., which cover the usual working day, in the morning vertical surfaces facing northwest are most unfavorably oriented for illumination from a clear sky, and in the afternoon vertical surfaces facing northeast. On the other hand, surfaces facing northwest are favorably oriented for skylight illumination in the afternoon, and those facing northeast, in the morning.

From Table IV and Figures 8, 9 and 10 we derive the following:

(1) With a cloudy sky the illumination on a vertical surface is practically independent of the orientation of that surface.

(2) With a cloudy sky the illumination on a horizontal surface is considerably more than twice that on a vertical surface, due to the fact that the point of maximum brightness of a cloudy sky is in or near the zenith.

(3) With high sun, as at midday in summer, the illumination from a cloudy sky exceeds that from a clear sky except on vertical surfaces facing the sun. This is not true with low sun, however.

The eight figures, 11 to 18, inclusive, give the illumination from clear skies on vertical surfaces oriented as indicated. Were it not for the fact that clear skies in July, August, September, October, and November, are on the average whiter and therefore brighter than clear skies in May, April, March, February, and January, respectively, the lines of equal illumination intensity would be nearly symmetrical on each side of a vertical line representing June 21.

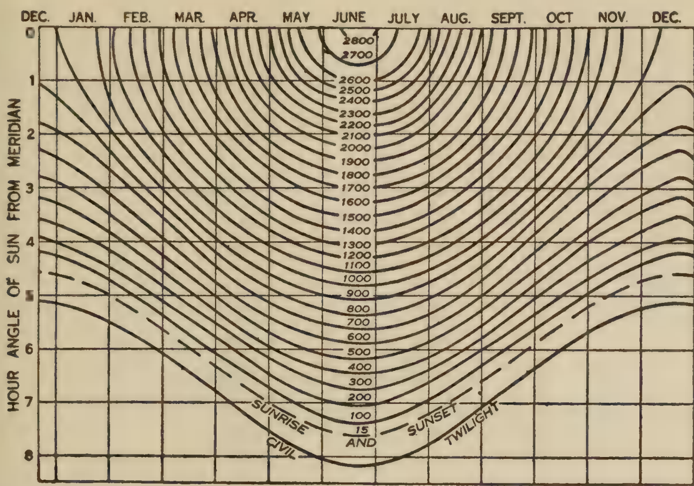


Fig. 9.—Illumination from a cloudy sky on a horizontal surface at latitude 2° north. Foot-candles.

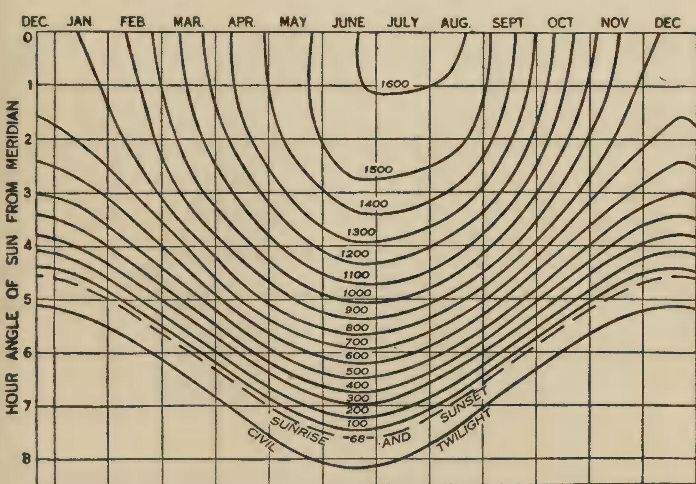


Fig. 10.—Illumination from a cloudless sky on a horizontal surface at latitude 2° north. Foot-candles.

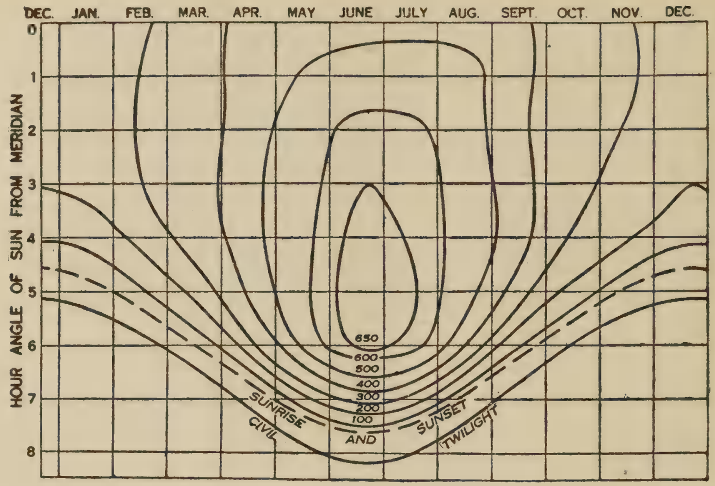


Fig. 11.—Illumination from a cloudless sky on a vertical surface facing north at latitude 42° north. Foot-candles.

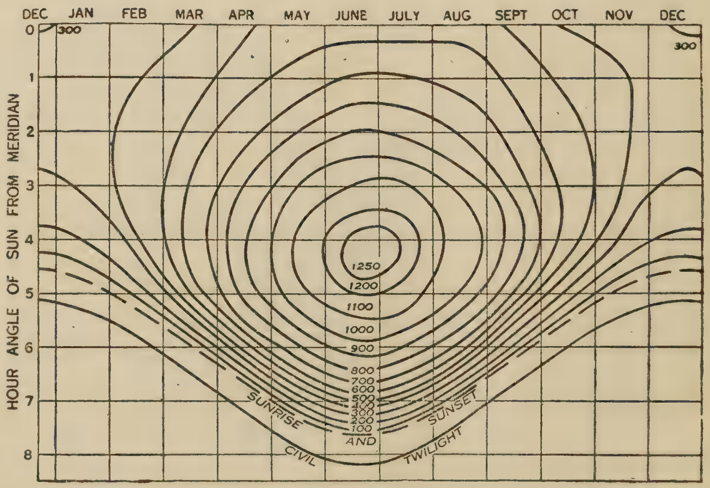


Fig. 12.—Illumination from a cloudless sky on a vertical surface facing northeast, A. M., or northwest, P. M., at latitude 42° north. Foot-candles.

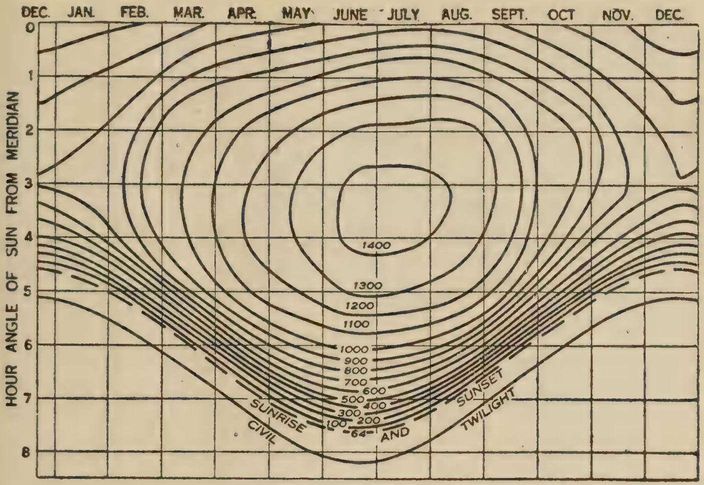


Fig. 13.—Illumination from a cloudless sky on a vertical surface facing east, . M., or west, P. M., at latitude 42° north. Foot-candles

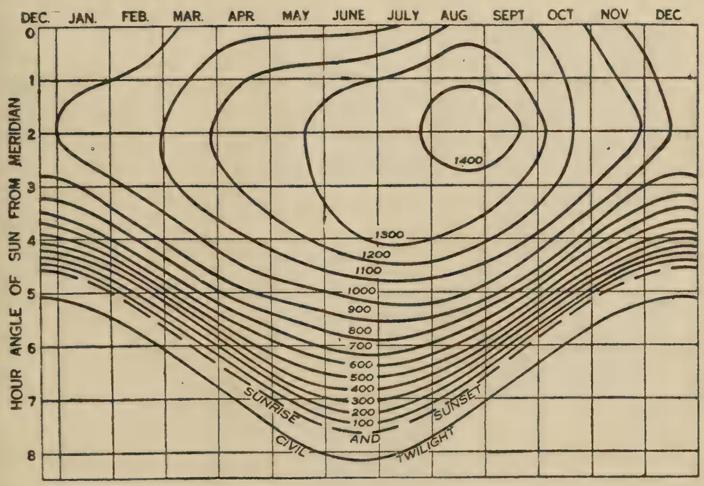


Fig. 14.—Illumination from a cloudless sky on a vertical surface facing south-east, A. M. or southwest, P. M., at latitude 42° north. Foot-candles.

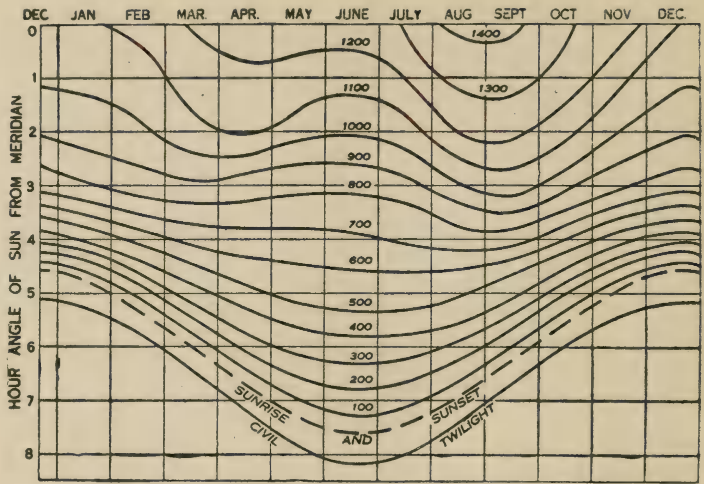


Fig. 15.—Illumination from a cloudless sky on a vertical surface facing south at latitude 42° north. Foot-candles.

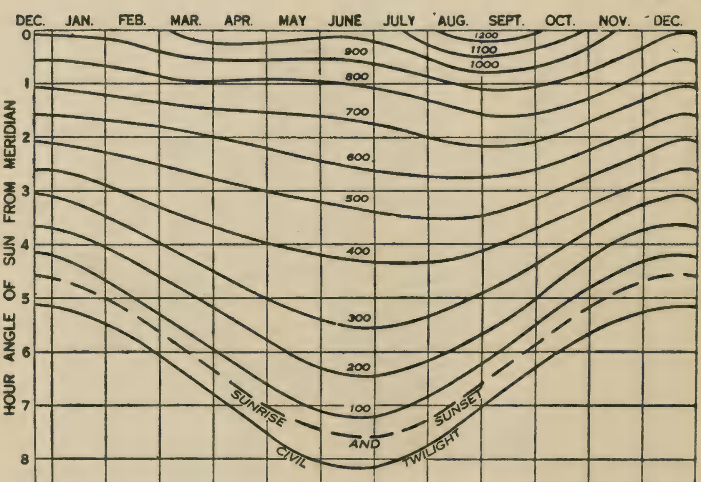


Fig. 16.—Illumination from a cloudless sky on a vertical surface facing south-west, A. M., or southeast, P. M., at latitude 42° north. Foot-candles.

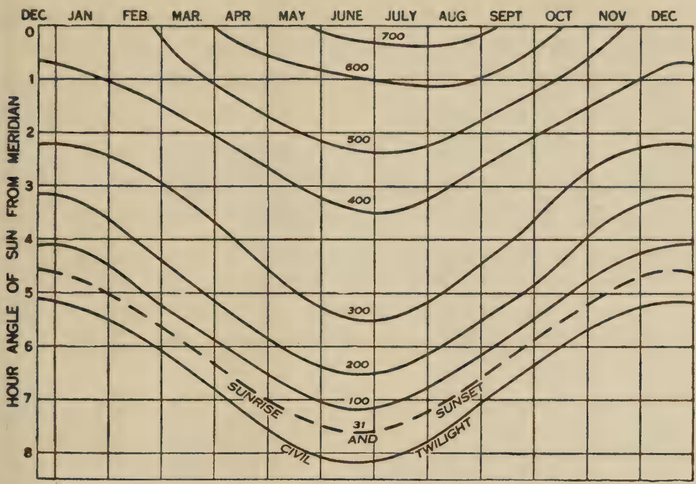


Fig. 17.—Illumination from a cloudless sky on a vertical surface facing west, M., or east, P. M., at latitude 42° north. Foot-candles.

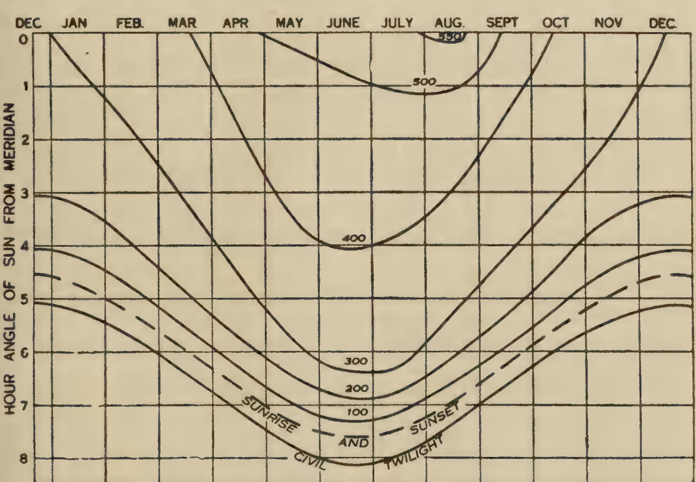


Fig. 18.—Illumination from a cloudless sky on a vertical surface facing north-est, A. M., or northeast, P. M., at latitude 42° north. Foot-candles.

These figures, like Figure 7, show the low intensity of clear-sk illumination during the morning hours on a vertical surfac facing northwest and during the afternoon hours on a vertica surface facing northeast. The maximum illumination, slightly i excess of 1,400 foot-candles, occurs late in August and in earl September at midday, on a vertical surface facing south; from th end of July to the latter part of September, on a vertical surfac facing southeast at 10 A. M., and southwest at 2 P. M., and from early in June to the middle of August, on a vertical surface facin east at 8:30 A. M., and west at 3:30 P. M. Illumination on a verti cal surface facing north is good throughout the day in summe but poor in winter.

In the report for 1921[4] it was shown that at the Federal Build ing, Chicago, which is in the smoky Loop District, the illumina tion on a vertical surface facing 180° from the sun is only abou two-thirds as intense as at Washington, while at the Universit of Chicago the sky-brightness and the illumination measurement differ but little from the corresponding Washington measure ments. Table V gives a summary of comparisons between Wash ington and Chicago illumination measurements on a horizonta surface, and on a vertical facing 180° from the sun, under winte conditions.

TABLE V.—RATIO, CHICAGO/WASHINGTON ILLUMINATION FROM WINTER SKIES

Federal Building: Solar altitude	Clear sky	Cloudy sky	University of Chicago: Solar altitude	Clear sky	Cloudy sky
ON HORIZONTAL SURFACE					
0°	0.49	0.90	0°	0.48	0.69
20°	1.05	0.77	20°	1.03	0.56
26°	0.84	0.82	29°	1.14	0.76
ON VERTICAL SURFACE FACING 180° FROM THE SUN					
0°	0.42	0.85	0°	0.46	0.55
20°	0.69	0.54	20°	0.84	0.56
26°	0.62	0.88	29°	0.97	0.98

[4] *Mo. Weather Rev.*, Sept., 1921, 49, p. 482 and p. 486.

The darkening effect of the smoke is rather more pronounced winter than in summer on a vertical surface facing away om the sun. The effect is slight at both seasons of the year on ırfaces facing the sun when no clouds are present, except when .e sun is near the horizon. The effect is closely related to the locity of the wind. With light wind, and especially when the y is covered with clouds, the smoke sometimes forms a cover blanket of great thickness which cuts off practically all the dayght. A dark day results, and artificial lighting is necessary outors as well as in. No such days are included in the sky-brightss measurements for Chicago here considered, although on nuary 4, with the sun 20° above the horizon, the zenith brightss was only 150 millilamberts, and 2° above the horizon it eraged only 37 millilamberts, while a measurement of the illumition on a horizontal surface gave only 34 foot-candles. A comrison with the corresponding data of Table IV shows that the nith brightness was 15 per cent and the illumination on a horintal surface 5 per cent that for Washington with average oudy conditions and the sun 20° above the horizon. The measements show that the smoke cloud varied greatly in intensity ıring the period of observation.

With a cloudless sky, and solar altitude 20°, in winter the innsity of direct solar illumination at normal incidence at Chigo averages about half the intensity at Washington; in summer, the Loop District, with solar altitudes 20° and 40°, about ree-fourths as intense.

At Washington, with a clear sky, the illumination measureents on both a horizontal and on a vertical surface vary beveen 150 per cent and 60 per cent of the values given in Table V. With a cloudy sky the variation is between 200 and 30 per nt. When rain is falling, the illumination is about half as great the average for cloudy skies; with a sky partly covered with ouds, the illumination on a horizontal surface may be from ree to four times as intense, and on a vertical surface two to ree times as intense, as the corresponding illumination from a ear sky given in Table IV.

From seasonal averages of sky brightness for Davos Platz, Switzerland, given by Dorno,[5] it appears that when expressed in terms of the zenith brightness the sky at Davos Platz opposite the sun is brighter than at Washington. The zenith brightness in winter averages more than 50 per cent brighter, and in summer a few per cent less bright at Davos Platz than at Washington. On the whole, Davos Platz skies when free from clouds are brighter in winter and less bright in summer than at Washington. Probably the increased brightness in winter is due in part to reflection of light from the snow-covered surface.

TOTAL SOLAR AND SKY ILLUMINATION

In the *Monthly Weather Review* for November, 1919, **47**, pp. 785, Table XIV, are given the illumination equivalents of solar energy expressed in heat units, with the sun at different altitudes. These equivalents were derived from simultaneous readings made at Mount Weather, Va., in 1913-14, with a pyrheliometer and a photometer. The photometer had its uncompensated test plate exposed horizontally, and the error, due to the oblique angle at which the sun's rays were received, was unknown.

TABLE VI.—ILLUMINATION EQUIVALENT OF 1 GRAM-CALORY PER MINUTE PER SQUARE CENTIMETER OF SOLAR ENERGY WITH THE SUN AT DIFFERENT ALTITUDES

Air mass. . . .	1.06	1.10	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
Solar altitude	70°0	65°0	42°7	30°0	23°5	19°3	16°4	14°3	12°6	11°3	10°2
Foot-candles .	7,040	7,020	6,880	6,740	6,650	6,580	6,520	6,460	6,410	6,370	6,320

In the measurements made at Washington in 1921-22 a *compensated* test plate was used, and the certificate furnished by the Electrical Testing Laboratories, New York, shows no appreciable error due to an obliquity in the angle of incidence of the sun's rays. Illumination intensities were measured with the test plate horizontal and also normal to the incident solar rays, but the latter measurements were given twice the weight of the former. Comparison of these measurements with simultaneous pyrheliometric measurements give the illumination equivalents of Table VI. These are considerably higher than the equivalents determined at Mount Weather, and particularly with low sun, as one would expect.

[5]Dorno, C. Himmelshelligkeit, Himmelspolarisation und Sonnenintensität in Davos 1911 bis 1918. Veröffentlichungen des Preusischen Meteorlogischen Instituts., Nr. 303. Abhandlungen Bd. VI, Tabellen 4A und 6.

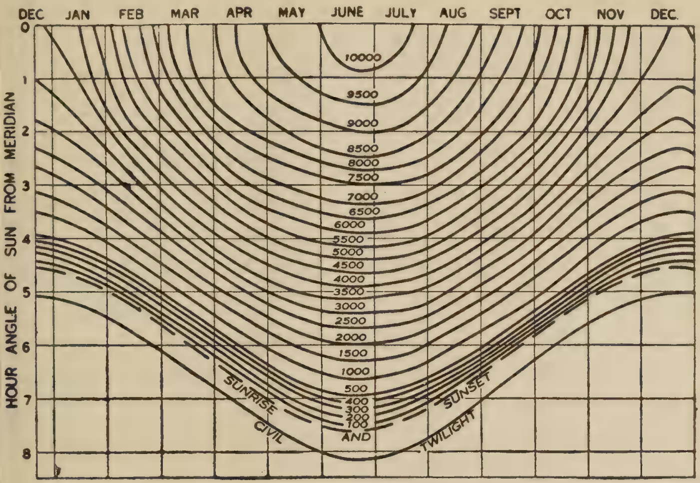


Fig. 19.—Total daylight illumination on a horizontal surface with a cloud- sky at latitude 42° north. Foot-candles.

3y means of the equivalents of Table VI and the solar radiation ensity at normal incidence for latitude 42° N., given in the mber of the *Review* above quoted (p. 773, Table Va), the ar illumination intensities of Table VII have been obtained.

BLE VII.—SOLAR ILLUMINATION INTENSITY AT NORMAL INCIDENCE AT LATITUDE 42° NORTH, WITH A CLOUDLESS SKY (EAST OF THE MISSISSIPPI RIVER)

Day	Hour angle of sun from meridian							
	0	1	2	3	4	5	6	7
ec. 21	7600	7300	6640	5190	2460	......	......	......
an. 21	8120	7890	7290	6040	3760	......	......	......
eb. 21	9140	9040	8440	7450	6140	2460	......	......
ar. 21	9270	9110	8710	7910	6700	4650	720	......
pr. 21	9230	9060	8800	8300	7350	5860	3600	......
ay 21	9070	8990	8630	8140	7480	6260	4700	1200
ine 21	9080	9000	8740	8220	7430	6420	4880	2160
ily 21	9070	8990	8670	8140	7550	6330	4830	1200
ug. 21	8810	8710	8390	7830	6880	5460	2990	......
ept. 21	8910	8760	8510	7710	6500	4590	720	......
ct. 21	8510	8420	7960	6910	5220	2100	......	......
ov. 21	8120	7890	7290	5960	3390	......	......	......

Representing the illumination intensities of Table VII by the illumination on a horizontal surface, I_h, and on a verti surface, I_v, may be obtained by the equations

$$I_h = I_n \sin a \quad (1)$$
$$I_v = I_n \cos a \cos \alpha \quad (2)$$

where a is the altitude of the sun, and α is the difference tween the sun's azimuth and the azimuth of a line normal to vertical surface. The surface will be illuminated by the sun c when the value of α is less than 90°.

Adding the values of I_h to the skylight-illumination values corresponding days and hours given on Figure 10, we obtain total daylight illumination on a horizontal surface for a cloud sky of average brightness at latitude 42° N., which is charted Figure 19.

Similarly, by adding the values of I_v for vertical surfaces fac the eight principal points of the compass to the skylight illum tion for corresponding days and hours given on Figures 11 to inclusive, we obtain the total daylight illumination on vertical s faces facing south; southeast A. M., or southwest P. M.; sou west A. M., or southeast P. M.; east A. M., or west P. M.; no east A. M., or northwest P. M.; and north; as given on Figu 20 to 25, inclusive.

It is to be noted that with north solar declination all vertical s faces receive direct solar radiation during only a part of the c During the remainder of the day the total daylight illumina is the same as the skylight illumination on Figures 11 to 18, clusive.

The data of Figures 1 to 25, inclusive, assume that the surf under consideration has an unobstructed exposure to the s Where a part of the sky is cut off by adjacent buildings or ot obstructions, the shading effect of such obstructions may be de mined by the method given in the previous report.[6]

This shading effect, and also the reflection of daylight fr surrounding objects, will receive more detailed consideration i later report.

[6] TRANS., Illum. Eng. Soc., Vol. XVI, p. 270; *Mo. Weather Rev.*, Sept., 192 p. 486.

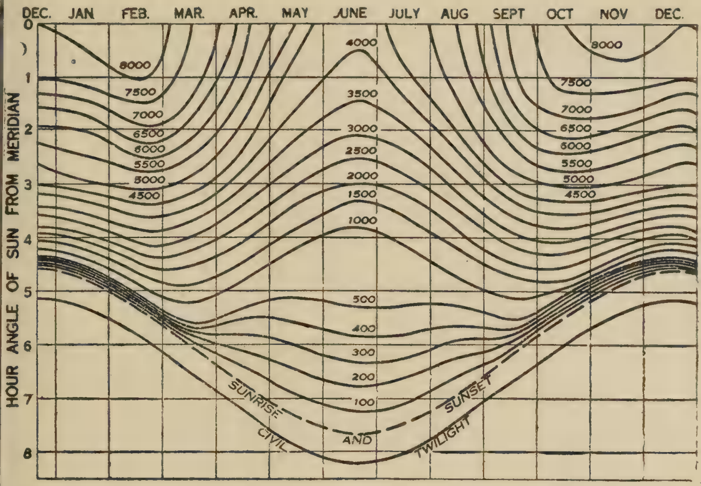


Fig. 20.—Total daylight illumination on a vertical surface facing south with loudless sky at latitude 42° north. Foot-candles.

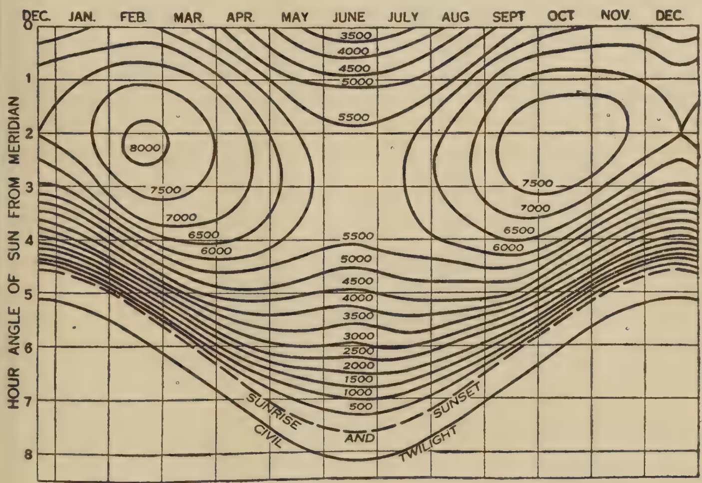


Fig. 21.—Total daylight illumination on a vertical surface facing southeast, M., or southwest, P. M., with a cloudless sky at latitude 42° north. Foot-candles.

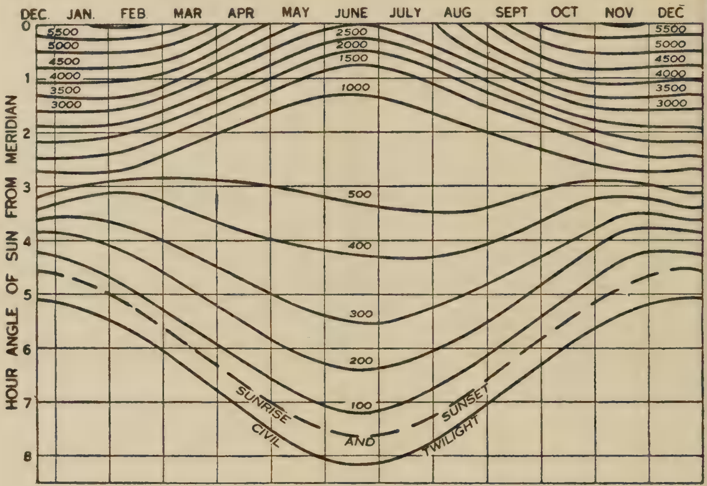


Fig. 22.—Total daylight illumination on a vertical surface facing southwe
A. M., or southeast P. M., with a cloudless sky at latitude 42° north. Foot-candl

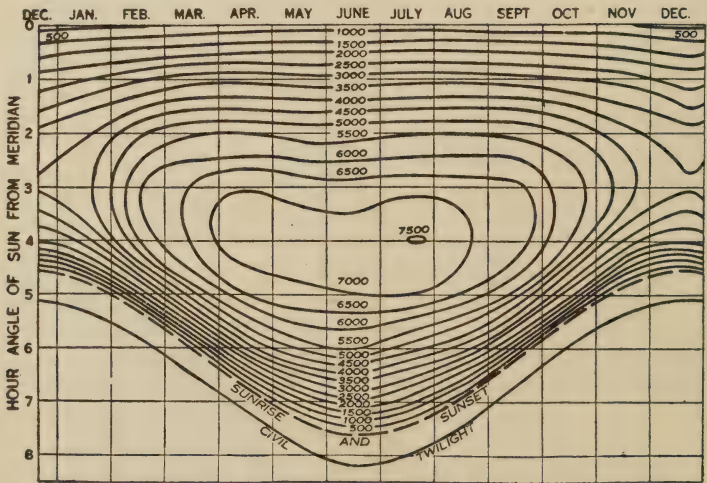


Fig. 23.—Total daylight illumination on a vertical surface facing east, A. M
or west P. M., with a cloudless sky at latitude 42° north. Foot-candles.

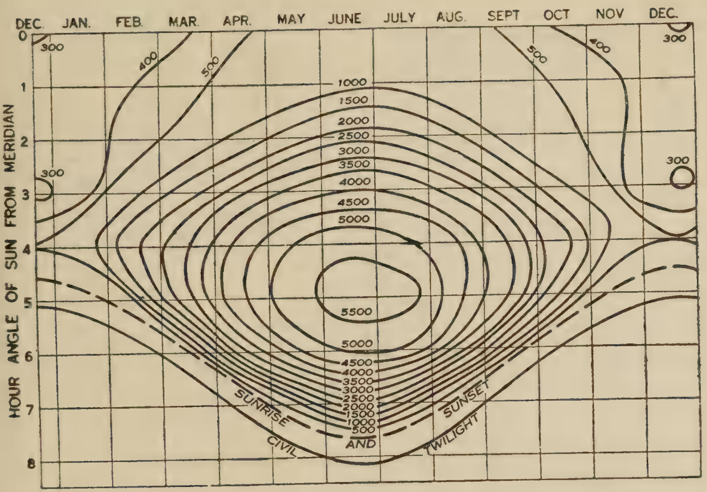


Fig. 24.—Total daylight illumination on a vertical surface facing northeast, . M., or northwest P. M., with a cloudless sky at latitude 42° north. Foot-candles.

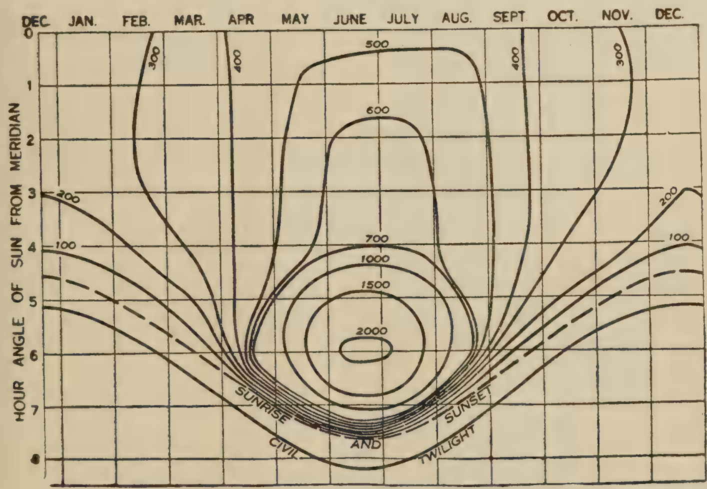


Fig. 25.—Total daylight illumination on a vertical surface facing north with , cloudless sky at latitude 42° north. Foot-candles.

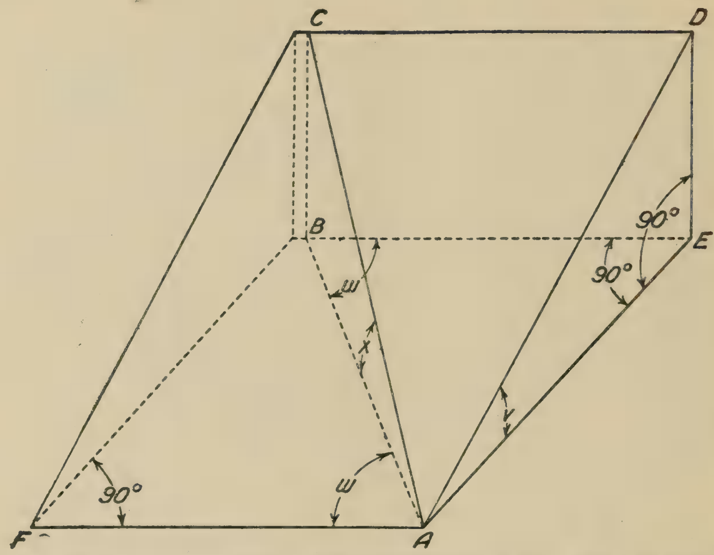


Fig. 26.—Determination of the angle of incidence of solar rays with a sloping surface.

DAYLIGHT ILLUMINATION ON SLOPING SURFACES

The intensity of solar radiation on surfaces sloping in different directions should be of importance to agriculturalists and engineers.[7] Illumination intensities on such surfaces are of especial interest in connection with the lighting of industrial plants by means of the so-called saw-tooth-roof construction.

The computation of direct solar illumination on sloping surfaces presents no special difficulties. Let v, Figure 26, represent the angle between the sloping surface and a horizontal surface; w, the difference between the azimuth bearing of AF, the intersection of these two surfaces, and AB, representing the sun's azimuth; and x, the angle between the intersections of a plane in the sun's vertical with the sloping surface and with a horizontal surface. Then

$$\tan x = \sin w \tan v, \text{ and } a' = a + x \qquad (3)^{8}$$

[7]*Mo. Weather Rev.*, Nov., 1919, 47, p. 781.

[8]In Daylight *vs.* Sunlight in Sawtooth-Roof Construction., *Transactions American Society of Mechanical Engineers*, 40, pp. 603-625, W. S. Brown derives this equation as follows:

$$\frac{AE}{ED} = \frac{\cos v}{\sin v} \quad \therefore \quad AE = ED \cot v.$$

Similarly, $AB = ED \cot x$; and $\sin w = \dfrac{AE}{AB} = \dfrac{\cot v}{\cot x}$, from which $\tan x = \sin w \tan v$.

ıere a is the altitude of the sun and a' is the angle between the ːident solar rays and the sloping surface.

To obtain the intensity of solar illumination on a sloping surːce we have only to substitute a' for a in equation (1).

We may also obtain a' by first determining the latitude and ıgitude of a point at which a horizontal surface is parallel to ɛ sloping surface, by the method given in the *Monthly Weather ːview*, November, 1919, **47**, p. 781.[9] Making allowance for the ːfference in time represented by the difference in longitude of ɛ sloping surface and its parallel horizontal surface, we may ːtain directly from an altitude table the altitude of the sun at ɛ latitude of the horizontal surface, and therefore the angle a' ıich the incident solar rays make with the sloping surface at any ːur of any day of the year.

The computation of the *skylight* illumination on sloping surːces requires the replotting of the sky-brightness measurements r each surface considered.

Figure 27 shows the data for a clear sky with the sun at altitude °, projected on a surface for which $90° - w = 45°$ and $v = 10°$ urface 80° out of the vertical and facing 45° in azimuth from e sun). In this case the zenith of the sky falls 10° from the nith of the sloping surface. The line of the horizon from aziuth + 45° to − 135° with reference to the sun, and the lines on ıich the sky-brightness measurements are to be plotted, have en determined by means of the methods given under Solution Problems in Stereographic Projections" (pp. 52-58), in General ıeory of Polyconic Projections, by Oscar S. Adams, United ːates Coast and Geodetic Survey, Special Publication No. 57, ːrial No. 110.

[9]NOTE.—In lines 15 and 16 from the bottom of the second column of the page ːerred to, the words "longitude" and "latitude" should be interchanged. The ːference in latitude between the sloping surface and its parallel horizontal surface given by the equation

$$\tan \Delta \phi = \frac{\cos \alpha'}{\cot v},$$

d the difference in longitude by the equation

$$\sin \Delta \lambda = \sin \alpha' \sin v$$

ːere α' is the azimuth in which the sloping surface faces, and v its angle of slope. ıen $\alpha' = 0°$ or 180°, $\sin \Delta \lambda = 0$, and tan = $\tan v$. That is, the sloping surface d the parallel horizontal surface have the same longitude, and the difference in ːitude equals the angle of slope, v.

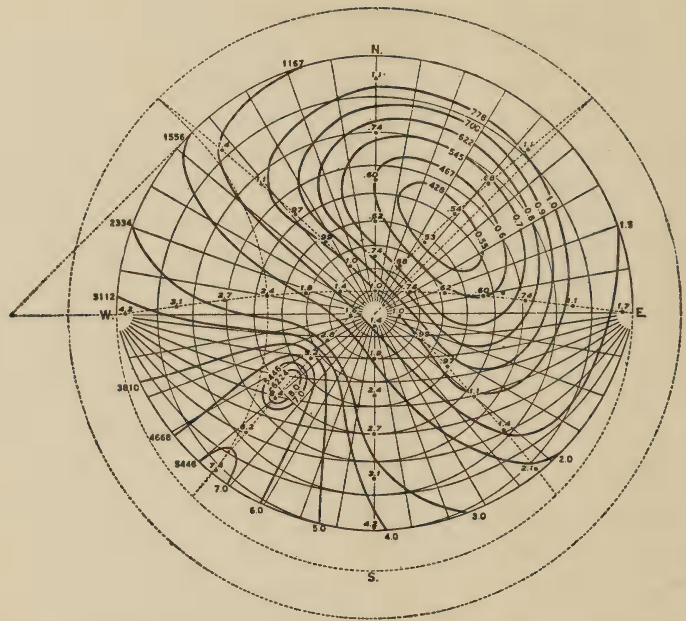


Fig. 27.—Stereographic projection of sky-brightness measurements on a slopi
surface.

It is to be noted that the location of the line of the horizc consists in passing a circle through two given points, when th center of the circle falls on a given line. Or, it may also be d termined by passing a circle through three given points, as is th location of the lines on which the sky-brightness measuremen are to be plotted.

On Figure 27 the brightness of the entire sky is shown with th exception of a spherical lune which falls below the plane of pro jection on the side WNE., and for which the maximum width 10° at N. The sky-brightness values that have been obtained b measurement on the half of the sky on one side of the sun's vert cal have been plotted on both sides of this vertical.

In Tables VIII and IX is given the total (solar + sky) illum nation on surfaces sloping in southerly directions, as indicatec In Tables X and XI is given the skylight illumination on surface sloping in northerly directions as indicated. In Table XII i given the ratio of the total illumination to the sky illumination o surfaces facing opposite each other in azimuth.

ABLE VIII.—Total Illumination on Surfaces Sloping South

Date	Hour angle of the sun from meridan							
	0	1	2	3	4	5	6	7
	Foot-candles							
	Surface sloping 10° from horizontal							
ec. 21	5,220	4,810	3,800	2,280	656	......	......	......
n. 21	6,000	5,590	4,560	2,910	1,140	......	......	......
eb. 21	7,890	7,520	6,280	4,480	2,240	486	......	......
ar. 21	9,250	8,800	7,660	5,880	3,660	1,560	82	......
pr. 21	10,230	9,780	8,700	7,040	4,910	2,640	720	......
ay 21	10,690	10,280	9,110	7.530	5,570	3,340	1,420	154
ne 21	10,980	10,530	9,460	7,830	5,820	3,730	1,720	280
ly 21	10,820	10,390	9,270	7,610	5,700	3,460	1,500	195
ug. 21	10,050	9,660	8,580	6,920	4,790	2,620	710	......
ept. 21	9,150	8,730	7,730	5.910	3,720	1,680	98	......
ct. 21	7,550	7,220	6,090	4,280	2,250	440	......	......
ov. 21	6,060	5,640	4,590	2,890	1,070	......	......	......
	Surface sloping 20° from horizontal							
ec. 21	6,300	5,820	4,690	2,890	900	......	......	......
an. 21	7,070	6,600	5,460	3,600	1,490	......	......	......
eb. 21	8,870	8,500	7,140	5,120	2,910	600	......	......
ar. 21	10,050	9,550	8,250	6,310	3,940	1,630	47	......
pr. 21	10,770	10,310	9,050	7,250	4,950	2,540	630	......
ay 21	11,060	10,490	9,230	7,510	5,400	3,100	1,180	141
une 21	11,260	10,640	9,460	7,750	5,610	3,360	1,380	232
uly 21	11,180	10,590	9,320	7,580	5,570	3,220	1,190	156
ug. 21	10,590	10,090	8,890	7,120	4,830	2,540	620	......
ept. 21	9,930	9,450	8,310	6,360	3,980	1,680	61	......
ct. 21	8,510	8,130	6,890	4,920	2,630	550	......	......
ov. 21	7,130	6,660	5,500	3,580	1,380	......	......	......
	Surface sloping 30° from horizontal							
ec. 21	7,220	6,680	5,410	3,440	1,140	......	......	......
an. 21	7,790	7,360	6,190	4,150	1,820	......	......	......
eb. 21	9,690	9,220	7,720	5,680	3,250	720	......	......
Mar. 21	10,640	9,990	8,590	6,550	4,110	1,700	50	......
pr. 21	11,100	10,340	9,040	7,120	4,870	2,390	470	......
May 21	10,960	10,320	8,990	7,260	5,100	2,740	875	134
une 21	10,970	10,320	9,150	7,420	5,200	2,960	1,040	230
uly 21	11,060	10,400	9,120	7,300	5,220	2,870	880	156
ug. 21	10,910	10,210	8,900	7,020	4,650	2,650	500	......
Sept. 21	10,520	9,860	8,660	6,650	4,180	1,800	62	......
ct. 21	9,250	8,790	7,420	5,380	2,940	650	......	......
Nov. 21	3,050	7,410	6,230	4,160	1,680	......	......	......

TABLE IX.—TOTAL ILLUMINATION ON SURFACES SLOPING TOWARD SOUTHEAST OR SOUTHWEST.

Date	Hour angle of sun from meridian														
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
	A. M. for surface sloping SE.; P. M., SW.								P. M. for surface sloping SE.; A. M., SW.						
	Foot-candles														
	Surface-sloping 10° from horizontal														
Dec. 21	....	....	....	816	2,530	3,920	4,680	4,830	4,120	3,080	1,620	302	....	....	....
Jan. 21	....	....	....	1,420	3,260	4,680	5,490	5,580	4,920	3,740	2,130	623	....	....	....
Feb. 21	....	....	756	2,980	4,950	6,500	7,420	7,370	6,780	5,330	3,500	1,610	180	....	....
Mar. 21	....	171	2,120	4,340	6,390	7,960	8,800	8,890	8,180	6,760	4,840	2,790	907	48	....
Apr. 21	....	1 240	3,330	5,630	7,600	8,990	9,730	9,970	8,140	7,930	6,010	3,890	1,850	305	....
May 21	366	2,090	4,160	6.310	8,060	9,400	10,360	10,480	9,790	8,320	6,600	4,580	2,530	850	180
June 21	589	2,380	4,520	6,620	8,470	9,880	10,690	10,770	10,050	8,900	6,970	4,900	2,920	1,180	235
July 21	336	2,210	4,240	6.520	8,260	9,640	10,520	10,600	9,920	8.570	6,730	4,760	2,640	902	160
Aug. 21	....	1,130	3,330	5.540	7,520	8,960	9,710	9,800	9,150	7,850	6.000	3,870	1,890	330	....
Sept. 21	....	190	2,170	4.380	6,430	8,010	8,730	8,820	8,130	6,890	4,920	2,850	839	63	....
Oct. 21	....	....	676	2,710	4,740	6,310	7,110	7,180	6,520	5,040	3,380	1,520	184	....	....
Nov. 21	....	....	....	1,320	3,230	4,700	5,540	5,640	4,970	3,760	2,110	594	....	....	....
	Surface sloping 20° from horizontal														
Dec. 21	....	....	....	1,260	3,360	4,880	5,560	5,550	4,650	3,310	1,580	232	....	....	....
Jan. 21	....	....	....	2,040	4,190	5,740	6,420	6,310	5,340	3,920	2,060	467	....	....	....
Feb. 21	....	....	1,130	3,990	6,020	7,560	8,340	8,120	7,150	5,380	3,250	1,270	157	....	....
Mar. 21	....	253	2,790	5,290	7,370	8,820	9,470	9,160	8,260	6,580	4,400	2,190	485	38	....
Apr. 21	....	1,610	3,960	6,590	8,400	9,720	10,290	10,170	9,030	7,500	5,330	3,100	1,060	270	....
May 21	505	2,440	4,670	6,910	8,660	10,000	10,800	10,470	9,610	7,770	5,790	3,640	1,640	418	140
June 21	713	2,700	4,990	7,180	9,000	10,340	11,040	10,720	9,730	8,130	6,100	3.930	1,920	540	190
July 21	412	2,550	4,790	7,160	8.850	10,220	10,920	10,610	9,650	8,020	5,910	3,820	1,700	450	120
Aug. 21	....	1,430	3,900	6,270	8,270	9,650	10,270	9,980	9,070	7,450	5,350	3,110	1,110	250	....
Sept. 21	....	276	2,770	5,220	7,370	8,910	9,430	9,260	8,250	6,700	4,530	2,300	500	52	....
Oct. 21	....	....	1,010	3,510	5,720	7,310	7,970	7,840	6,870	4,900	3,160	1,200	163	....	....
Nov. 21	....	....	....	1,880	4,160	5,730	6,480	6,360	5,350	3,950	2,050	451	....	....	....
	Surface sloping 30° from horizontal														
Dec. 21	....	....	....	1,670	4,180	5,740	6,280	6,080	4,960	3,380	1,530	175	....	....	....
Jan. 21	....	....	....	2,660	5,090	6,580	7,140	6,800	5,580	3,970	1,940	325	....	....	....
Feb. 21	....	....	1,490	4,850	6,940	8,410	8,950	8,480	7,290	5,220	2,900	859	174	....	....
Mar. 21	....	334	3,230	5,910	8,090	9,500	9,930	9,460	8,140	6,240	3,880	1,600	450	46	....
Apr. 21	....	1,990	4,600	7,150	9,040	10,340	10,650	10,010	8,700	6,850	4,560	2.240	540	250	....
May 21	467	2,830	5,150	7,380	9,120	10.360	10,860	10,140	8,900	7,040	4,860	2,610	651	284	120
June 21	821	2,970	5,380	7,490	9,280	10,570	10,960	10,270	9,070	7,240	5.020	2,770	820	410	180
July 21	470	2,910	5,240	7,550	9,180	10,550	10,970	10,240	9,050	7,180	4,850	2,700	703	380	110

ABLE X.—SKYLIGHT ILLUMINATION ON SURFACES SLOPING NORTH

Date	Hour angle of sun from meridian							
	0	1	2	3	4	5	6	7
	Foot-candles							
	Surface sloping 10° from vertical							
ec. 21	310	310	285	221	115	......	......	......
n. 21	320	330	310	259	160	......	......	......
eb. 21	340	352	348	340	293	112	......	......
ar. 21	421	428	406	429	436	327	48	......
pr. 21	520	540	562	564	550	485	346	......
ay 21	554	600	660	685	641	650	590	228
une 21	580	640	758	770	740	790	719	365
uly 21	580	635	733	730	712	700	630	288
ug. 21	570	605	610	635	629	560	371	......
ept. 21	468	480	462	494	487	354	72	......
ct. 21	368	386	372	374	331	147	......	......
ov. 21	333	343	328	270	167	......	......	......
	Surface sloping 20° from vertical							
ec. 21	355	350	320	236	112	......	......	......
an. 21	362	365	355	276	172	......	......	......
eb. 21	390	400	410	395	294	120	......	......
ar. 21	489	498	471	516	486	416	46	......
pr. 21	619	635	638	640	642	589	412	......
ay 21	660	720	782	805	759	764	625	241
une 21	698	777	888	901	956	879	750	365
uly 21	691	760	874	860	834	817	720	312
ug. 21	671	710	715	730	730	660	418	......
ept. 21	542	560	538	558	555	411	60	......
ct. 21	430	446	460	420	338	122	......	......
ov. 21	378	394	366	278	182	......	......	......
	Surface sloping 30° from vertical							
Dec. 21	377	380	345	255	120	.....	......	......
Jan. 21	398	407	384	302	172	......	......	......
Feb. 21	431	450	441	424	341	147	......	......
Mar. 21	569	575	524	572	582	451	47	......
Apr. 21	754	760	742	753	745	651	409	......
May 21	801	873	913	882	898	871	643	200
June 21	830	920	1,035	1,028	1,035	1,004	770	337
July 21	837	917	998	990	980	962	655	217
Aug. 21	828	870	840	837	850	735	442	......
Sept. 21	631	645	596	630	626	465	58	......
Oct. 21	473	497	502	472	378	189	......	......
Nov. 21	413	423	417	323	200	......	......	......

TABLE XI.—SKYLIGHT ILLUMINATION ON SURFACES SLOPING NORTHEAST OR NORTHWEST

Date	Hour angle of sun from meridian														
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
	A. M., sloping NE.; P. M., sloping NW.								P. M., sloping NE.; A. M., sloping NW.						
	Foot-candles														
	Surface sloping 10° from vertical														
Dec. 21 . .	. .	. .	. .	122	292	380	380	336	317	298	186	108	. .	. .	. .
Jan. 21 . .	. .	. .	. .	220	355	418	418	351	330	307	245	142	. .	. .	. .
Feb. 21 . .	. .	. .	152	457	503	478	445	375	360	338	308	236	97	. .	. .
Mar. 21 . .	. .	80	630	780	660	614	544	465	425	373	370	325	245	42	. .
Apr. 21 . .	. .	650	985	990	920	790	700	569	527	465	410	375	320	220	. .
May 21 . .	450	1,150	1,300	1,240	1,100	1.010	815	624	575	540	485	425	430	330	150
June 21 . .	600	1,350	1,500	1,325	1,383	1,070	900	661	600	590	533	478	475	400	180
July 21 . .	450	1,220	1,500	1,300	1,130	1,200	870	660	600	585	510	440	450	380	120
Aug. 21 . .	. .	900	1,110	1,080	1,080	1.000	830	640	588	520	465	430	355	275	. .
Sept. 21 . .	. .	108	700	860	760	670	655	529	470	420	400	360	260	47	. .
Oct. 21 . .	. .	. .	185	496	597	562	529	402	358	335	310	230	97	. .	. .
Nov. 21 . .	. .	. .	. .	268	376	444	488	372	345	308	242	148	. .	. .	. .
	Surface sloping 20° from vertical														
Dec. 21 . .	. .	. .	. .	170	337	405	440	391	370	308	225	105	. .	. .	. .
Jan. 21 . .	. .	. .	. .	230	402	480	525	418	385	340	257	145	. .	. .	. .
Feb. 21 . .	. .	. .	202	502	580	580	565	440	420	380	345	250	98	. .	. .
Mar. 21 . .	. .	78	640	755	785	705	660	547	495	425	370	360	245	38	. .
Apr. 21 . .	. .	720	980	1,050	1,010	935	810	676	625	550	485	440	355	225	. .
May 21 . .	450	1,050	1,360	1,280	1,190	1,125	935	747	690	655	560	490	500	360	130
June 21 . .	600	1,350	1,500	1,420	1,300	1,210	1,070	800	730	685	630	530	570	450	165
July 21 . .	450	1,220	1,500	1,320	1,300	1,195	1,020	792	715	675	605	508	530	420	115
Aug. 21 . .	. .	900	1,080	1,140	1,220	1,080	920	760	685	610	535	480	390	240	. .
Sept. 21 . .	. .	105	680	935	1,010	803	750	624	560	492	450	375	262	44	. .
Oct. 21 . .	. .	. .	185	500	684	680	638	488	460	425	365	260	91	. .	. .
Nov. 21 . .	. .	. .	. .	247	424	518	556	440	394	340	275	125	. .	. .	. .
	Surface sloping 30° from vertical														
Dec. 21 . .	. .	. .	. .	220	320	430	480	420	387	340	255	135	. .	. .	. .
Jan. 21 . .	. .	. .	. .	285	455	550	580	448	422	375	294	164	. .	. .	. .
Feb. 21 . .	. .	. .	202	530	660	645	592	491	450	428	400	277	107	. .	. .
Mar. 21 . .	. .	69	625	840	975	980	790	640	570	486	425	385	290	42	. .
Apr. 21 . .	. .	755	910	950	1,200	1,050	920	824	785	650	525	475	385	240	. .
May 21 . .	450	1,050	1,320	1,350	1,380	1,300	1,100	888	830	800	665	530	535	390	120
June 21 . .	600	1,350	1,500	1,450	1,360	1,350	1,180	941	855	840	738	595	600	445	220
July 21 . .	450	1,220	1,500	1,400	1,400	1,320	1,160	949	870	835	695	575	535	420	140
Aug. 21 . .	. .	900	1,085	1,270	1,320	1,200	1,070	928	850	720	620	510	425	270	. .
Sept. 21 . .	. .	100	740	960	810	857	910	730	627	535	485	420	310	48	. .
Oct. 21 . .	. .	. .	215	580	784	750	847	524	505	470	415	275	107	. .	. .
Nov. 21 . .	. .	. .	. .	326	510	620	590	484	440	380	285	167	. .	. .	. .

TABLE XII.—RATIO OF TOTAL ILLUMINATION, T, TO SKY ILLUMINATION, S

CLOUDLESS SKY, LATITUDE 42° N.

Date	Hour angle of sun from meridian							
	0	1	2	3	4	5	6	7
	T, vertical surface facing south; S, vertical surface facing north							
ec. 21	29	27	22	22	16	......	......	......
eb. 21	28	26	22	17	12	8	......	......
pr. 21	13	12	10	7	4	1.4	0.3	......
ine 21	9	7	5	3	1.1	0.3	0.2	0.1
ug. 21	12	11	9	6	3	1	0.5	......
ct. 21	25	23	20	15	11	5	......	......
	T, surface sloping south 10° from horizontal; S, sloping north 10° from vertical							
ec. 21	18	16	13	10	6	......	......	......
eb. 21	23	21	18	13	8	4	......	......
pr. 21	20	18	16	12	9	5	2	......
ine 21	19	16	12	10	8	5	2	0.8
ug. 21	18	16	14	11	8	5	2	......
ct. 21	20	19	16	11	7	3	......	......
	T, surface sloping south 30° from horizontal; S, sloping north 30° from vertical							
ec. 21	19	18	16	14	10	......	......	......
eb. 21	22	20	18	13	10	5	......	......
pr. 21	15	14	12	10	6	4	1.2	......
ine 21	13	11	9	7	5	3	1.4	0.7
ug. 21	13	12	11	8	6	4	1.1	......
ct. 21	20	18	15	11	8	3	......	......

HOUR ANGLE OF SUN FROM MERIDIAN

Date	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
	T, surface facing SE., A. M., or SW., P. M. S, surface facing NW., A. M., or NE., P. M.								T, surface facing SW., A. M., or SE., P. M. S, surface facing NE., A. M., or NW., P. M.						
	Surfaces vertical														
ec. 21	...	...	...	28	29	28	24	20	12	7	2	0.7	...	...	...
eb. 21	...	...	30	30	28	28	24	19	10	4	0.9	0.6	0.5	...	...
pr. 21	...	14	17	22	21	17	13	9	4	0.9	0.6	0.4	0.3	0.3	...
ne 21	6	8	11	16	14	11	9	6	1.6	0.7	0.5	0.3	0.3	0.3	0.3
ug. 21	...	11	15	18	18	15	12	8	3	0.9	0.6	0.4	0.3	0.3	...
ct. 21	...	...	24	25	25	24	20	16	9	4	0.9	0.6	0.5	...	...

TABLE XII.—(*Continued*)—RATIO OF TOTAL ILLUMINATION, T, TO SKY ILLUMINATION, S

Date	HOUR ANGLE OF SUN FROM MERIDIAN														
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
	T, surface sloping 10° from horizontal; S, 10° from vertical														
Dec 21..........	...	...	...	8	14	13	15	14	11	8	6	2	...	...	..
Feb. 21..........	...	...	8	13	16	19	21	20	15	11	7	4	1.2	...	..
Apr. 21..........	...	6	10	15	18	19	18	17	13	10	6	4	2	0.5	..
June 21..........	3	6	10	14	16	17	17	16	11	8	5	4	2	0.9	0.4
Aug. 21..........	...	4	9	13	16	17	18	15	11	8	6	4	2	0.4	..
Oct: 21..........	...	...	7	12	15	19	20	18	12	9	6	3	1.0	...	..
	T, surface sloping 30° from horizontal; S, 30° from vertical														
Dec. 21..........	...	...	...	12	16	17	16	14	10	8	5	0.8	...	...	..
Feb. 21..........	...	...	14	18	18	20	20	17	12	8	4	1.6	0.9	...	..
Apr. 21..........	...	8	12	15	17	16	14	12	9	7	4	2.4	0.6	0.3	..
June 21..........	4	7	9	13	13	13	13	11	8	5	4	1.9	0.7	0.3	[illegible]
Aug. 21..........	...	7	10	13	14	14	12	11	8	6	3	1.7	0.5	0.3	..
Oct. 21..........	...	...	12	16	16	17	17	16	8	6	4	1.4	0.7	...	..

Table VIII shows that in general on surfaces sloping south an with south solar declination the total illumination increases with With north solar declination the illumination reaches a maximu in the middle of the day when v equals about 20°, and decrease as v increases with the sun near the horizon.

Table IX shows that in the morning on surfaces facing soutl east, and in the afternoon on surfaces facing southwest, there an increase in the total illumination with increase in v, excep near midday in midsummer with v greater than about 20°. Als in the morning, on surfaces facing southwest, and in the afternoo on surfaces facing southeast, the illumination generally decrease with increase in v, except near midday with south solar declina tion.

Tables X and XI show an increase with v in skylight illumina tion on vertical surfaces sloping northward, as one would expec It must be remembered, however, that with saw-tooth construc tion a very considerable part of the skylight is cut off by shadin

his is unimportant when considering the total illumination on rfaces sloping in a southerly direction, but becomes important connection with the skylight illumination on surfaces facing wards the north, since it is the brightest part of the sky that is t off.

Let it be assumed that the ridges of the saw-teeth of the roof e horizontal, and of infinite length, and let $\theta =$ the maximum gular width of the spherical lune of the sky cut off. Then ble XIII gives the percentages of decrease in the skylight illu-

BLE XIII.—SHADING EFFECT IN SAW-TOOTH ROOF CONSTRUCTION

$90^\circ - w$.	Solar altitude 20°	40°	60°	70°	θ
	PERCENTAGE OF SKYLIGHT CUT OFF				
°	Surface 10 degrees out of vertical				°
180	32	24	20	17	10
135	26	25	18	17	10
90	25	19	17	15	10
	Surface 20 degrees out of vertical				
180	43	37	31	25	
	Surface 30 degrees out of vertical				
180	39	33	24	21	20
135	38	28	23	21	20
90	34	26	24	18	20
180	53	44	33	31	30
135	50	41	33	28	30
90	46	37	33	30	30
	Surface 60 degrees out of vertical				
0	19	11	6	6	10
45	14	9	6	5	10
90	9	7	5	4	10
0	53	39	23	21	30
45	44	32	22	21	30
90	28	22	18	16	30
	Surface 80 degrees out of vertical				
0	11	6	3	3	10
45	9	5	3	3	10
90	4	3	2	2	10
0	35	29	18	15	30
45	32	21	13	12	30
90	16	12	10	9	30
0	64	54	36	30	50
45	55	42	28	27	50
90	30	23	20	19	50

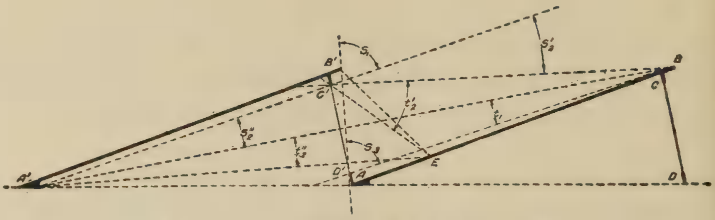


Fig. 28.—Cross section of a saw-tooth roof.

mination,[10] due to shading by the adjacent saw tooth.

Table XII shows that during most of the working hours of th day (except in midsummer) the total daylight illumination o surfaces sloping southward exceeds by more than tenfold the sky light illumination on surfaces sloping northward.

Computations from the sky-brightness data given in TRANS ACTIONS, Illuminating Engineering Society, Vol. XVI, p. 260, Fig ures 6 and 7, show that skylight illumination on vertical or sloping surfaces facing away from the sun is about twice as intense whe the sky is covered with thin clouds or haze or partly covered wit white clouds, which is its usual condition, as when clear. Th total (solar + sky) illumination on surfaces facing the sun i usually diminished by the presence of haze or clouds of the abov character. In consequence, when the angle w lies between abou 45° and 135°, the ratios of Table XII will be diminished, on th average, by at least one-half, and will vary in value from thei maxima with clear-sky conditions, given in Table XII, to abou 2 for a sky completely covered with dense clouds. This wil be made clear from a comparison of the sky-brightness data o Figures 4 (opposite p. 259) and 13 (p. 263) with Figures 6, 7 and 8 (p. 260) and 11 (p. 262), TRANSACTIONS, Illuminatin Engineering Society, Vol. XVI, October, 1921, and Figure 3 (p 442) of this paper; and by reference to the illumination intensitie of Table IV (p. 443) of this paper.

These ratios are of use in computing the daylight that can b made available for illuminating working space in a buildin through saw-tooth-roof construction. In general, there are tw sources from which the light may be obtained as follows:

[10]The percentages of Table XIII have been computed from Figure 27 and othe similar figures. See also TRANS., Illum. Eng. Soc., Vol. XVI, p. 270 and *Mo. Weathe Review*, Sept., 1921, 49, p. 486.

) Light from the northern sky incident at the working e, or reflected thereto from the ceiling of the saw-tooth roof angles S_1 to S_3, and S'_2 to S''_2, respectively, Figure 28).

) Solar and skylight reflected from the outside surface of aw-tooth directly to the working space, or through a second- eflection from the ceiling of the saw-tooth roof (roof angles o, and t'_2 to t''_2, Figure 28).

is to be understood that the angles here shown are cross- ons of spherical wedges.

ssuming the ratio of the intensity of the total light reaching outherly-sloping roof surface of a saw-tooth window, AB ure 28) to the light received from the sky on the northerly- ng window surface C′D′ (Figure 28) to be 4, Brown[11] com- d the relative values of (1) and (2) to be 14.6 and 6.1, ectively.

t us consider a saw-tooth construction that gives a window ace facing north and sloping 20° from the vertical, and a roof ace sloping south 20° from the horizontal. Let the latitude 2° north, the sky clear, the date March 21, and the hour 10 I., or 2 P. M., apparent time. The solar altitude will be 40° its azimuth 41°. Disregarding shading, Tables VIII and X 8,250 and 471 foot-candles for the illumination intensity on oof surface and the window surface, respectively, the ratio e former to the latter being 18.

e ridge of the adjacent saw tooth would cut off from the ow a spherical wedge near the horizon for which the average e of θ would be about 10°. The window is facing 139° from un, and from Table XIII it is estimated that the shading by oof diminishes the skylight illumination at the window sur- 20 per cent. The roof between B and E will be in sunlight, between E and A it will be illuminated by skylight only. We therefore disregard the small quantity of light this latter can ct to the under side of A′B′. The skylight from a spherical near the southern horizon for which θ averages about 30° be cut off from BE by the adjacent saw tooth. From Table I we estimate that the illumination from skylight will be de- sed by about 27 per cent. Therefore, the available sky illu- ation on the north-sloping window surface is 471 × 0.80

[11] Loc. cit., p. 620.

= 377, and on the south-sloping roof surface it is 1,100 × 0. = 800 foot-candles. The total illumination on the south-slopi roof surface is 7,950 foot-candles, and its ratio to the illuminati on the window surface is 7,950/377 = 21. Substituting t value for 4, we obtain for the relative values of (1) and (2) 1 and 32, respectively. Or, if we suppose the sky to be cover with thin clouds, or partly covered with white clouds the val become 11.6 and 16.

Apparently, therefore, for clear-sky conditions, or even f the most usual sky conditions, when thin clouds or haze, scattered white clouds are present, most of the daylight receiv through a saw-tooth-roof window will be from the reflection skylight and sunlight from the roof of an adjacent saw tooth. cloudy weather, however, nearly all the light will be received fr the northern sky.

No attempt has been made to express the illumination intens at the working space in absolute units. In order to do so, it necessary to know the average of the solid sky angles S_1 and and of S'_2 and S''_2 (Figure 28); the brightness of the sky i cluded in each of these angles, from which the sky illuminati may be computed; the solar illumination intensity on the roof su face BE; the solid roof angle t_1 and the average of the solid ro angles t'_2 to t''_2; the coefficients of reflection of the surface of t ceiling A′B′, and the roof, BE; the solid angle subtended by t ceiling at the working space, and the angle at which light is i cident at the roof or the ceiling, and is received at the worki space either directly or by reflection from the outside roof or t inside ceiling.

Of the above factors the brightness of the sky and the intensi of the solar illumination are given with reasonable accuracy this paper for latitude 42° N. The remaining factors depe upon the design of the saw-tooth roof and its window openin and must be determined for each individual case.

During the winter months, in a smoky city like Chicago, dis garding the probable decrease in the reflecting power of the ce ing of A′B′, and the roof surface BE, the absolute values (1) and (2) can not exceed two-thirds and one-half, respective of their values in a comparatively smokeless region.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS apers of general interest pertaining to the field of illumination apng in technical journals, (2) ABSTRACTS of papers presented before Illuminating Engineering Society, and (3) NOTES on research prob- now in progress.

NOTE ON THE INTEGRATING SPHERE REFLECTOMETER

BY JOHN W. T. WALSH*

convenient form of absolute reflectometer consists of an richt sphere with a small aperture which is covered by the ace under test so that this receives an almost perfectly dif-d illumination when a beam of light is projected on to sphere wall. If the test surface be screened from the illumi-d patch on the sphere, the flux received by the test surface lumens per unit area if the brightness of the general surface he sphere is b lamberts. It follows that the brightness of the surface is ρ b lamberts *if this surface is perfectly diffusing,* ing its reflection factor. Thus ρ may be found by compar-the brightness of the test surface with that of the sphere wall. is clear that the same result holds when the test surface perfect mirror, for in this case the brightness of the surface hat of an image of a portion of the sphere wall seen in the ror. The conclusion has been drawn from this result that method is universally applicable, whether the test surface be erfect diffuser or not,[1] but a closer consideration of the blem will show that this cannot be the case.

et A, Fig. 1, be an element of surface which is not perfectly using and let IA represent a ray of light incident at the angle the plane of the paper. Let AM (also in the plane of the er) be the direction of specular reflection of IA and let AE ny other direction (not necessarily in the plane of the paper).

* M. A., M. Sc., F. Inst. P., The National Physical Laboratory, England.

[1] C. H. Sharp and W. F. Little, Illuminating Engineering Society., N. Y., TRANS., 1920, p. 804. E. Karrer, *Opt. Soc. Am., J.*, 5, 1921.

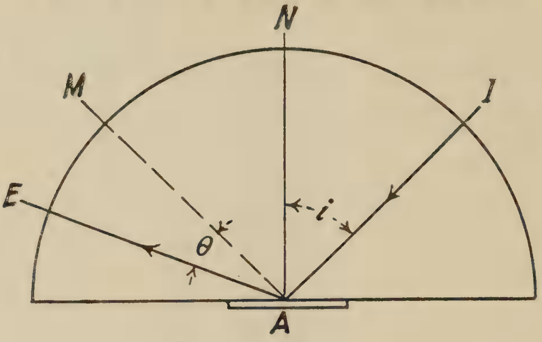


Fig. 1.

Then the brightness of A when viewed along AE is proportion to the illumination of A due to the light IA and to some functi of the angles NAI, MAE and NAE.

It is legitimate to consider the special case when this fun tion is independent of one of these angles,[2] and for convenien in calculation it will be assumed that this function depends c the angles NAI and MAE only and may therefore be writt $f(i, \theta)$ where $i =$ NAI and $\theta =$ MAE. This assumption impli that the brightness of the surface is the same in all directio equally inclined to the direction of specular reflection of th incident light.

Now referring to Fig. 2, let A be an element of surface, an let AY be the normal. In this case let AE, the direction fro which the surface is viewed, be in the plane of the paper, an let IA, the direction of the incident light, make an angle ϕ wit the plane of the paper. Also let the projection of IA on th plane of the paper make an angle ψ with AY. Then the ang EAI is given by $\cos \text{EAI} = \cos \phi \cos (\psi + \epsilon)$.

Also, it is clear that if AI_1 be the direction of specular reflectio of IA,

$$\cos \theta = \cos \text{EAI}_1 = \cos \phi \cos (\psi - \epsilon) \ldots\ldots\ldots (1$$

The angle of incidence of the light is given by

$$\cos i = \cos \text{YAI} = \cos \phi \cos \psi \ldots\ldots\ldots\ldots\ldots (2$$

so that if the surface A receive perfectly diffused flux, (*i. e.*, flu of which the density is the same in all directions) the illumina

[2] If the function is independent of all three the surface is a perfect diffuser.

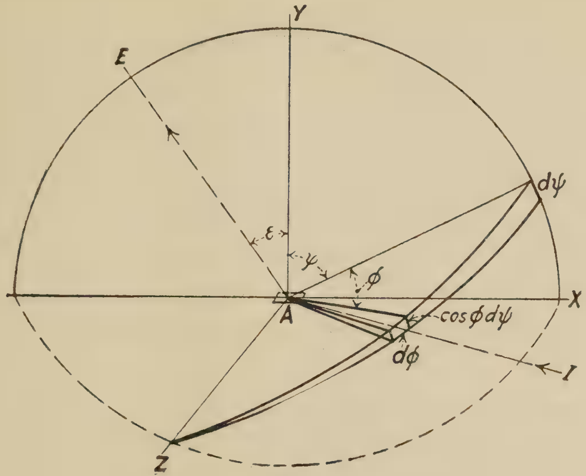


Fig. 2.

ion E_i due to the light incident within the cone whose solid angle s $\cos\phi\, d\psi\, d\phi$ and whose axis is IA (see Fig. 2) may be written

$$E_i = F \cos i \cos\phi\, d\psi\, d\phi$$
$$= F \cos^2\phi \cos\psi\, d\psi\, d\phi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

The brightness of A in the direction AE, due to this illumination is, then $B_i = Ff(i, \theta) \cos^2\phi \cos\psi\, d\psi\, d\phi$

From a consideration of Fig. 2 it will be seen that the total brightness of A in the direction AE is given by

$$B = 2F \int_{\phi=0}^{\phi=\frac{\pi}{2}} \int_{\psi=-\frac{\pi}{2}}^{\psi=+\frac{\pi}{2}} f(i, \theta) \cos^2\phi \cos\psi\, d\psi\, d\phi \quad \ldots\ldots\ldots \text{(4)}$$

If the surface be a perfect diffuser, $f(i, \theta)$ is a constant ($= \rho$) and the above expression reduces to $\pi\rho F$ as is to be expected since the total flux incident on the surface per unit area, *i. e.* the total illumination, is πF.

If, however, the surface be not a perfect diffuser, $f(i, \theta)$ is not independent of i, and θ, *i.e.* of ϵ, and *the brightness of the surface will depend on the angle of view,* and will not be independent of it as has been generally assumed hitherto.

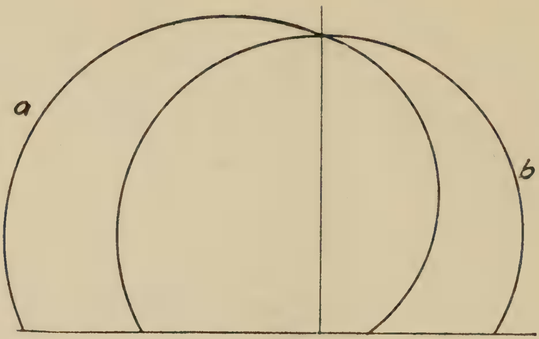


Fig. 3.

The degree of importance of this effect in particular cases may be gauged by assuming a special form for $f(i, \theta)$. This function should clearly have a maximum value when $\theta = 0$ and it should not become negative for any value of θ.

It also seems desirable to assume a form for $f(i, \theta)$ which leads to a value for the reflection factor of the surface (ratio of emitted flux to flux received) that is independent of the angle of incidence of the light. The function $m(1 + k \sec i \cos \theta)$ fulfills these conditions, i being the angle of incidence and θ, as before, the angle between the direction of view and the direction of specular reflection.

The polar curve of such a surface, when $i = 45°$, and $k = 0.7$, (a) in the plane of the incident light and (b) in a perpendicular plane, is shown in Fig. 3, from which it will be seen that this is a very reasonable distribution to assume for such a surface as that of slightly glazed paper.[3]

It is easily shown that with this form of $f(i, \theta)$ the reflection factor is independent of i for the flux incident at the surface per unit area is clearly F cos i while the total flux emitted is (Fig. 2)

$$2\int_0^{\frac{\pi}{2}}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} (F \cos i/\pi)\, m \quad (1 + k \sec i \cos\theta)\ \cos\phi \cos\psi \cos\phi\, d\psi\, d\phi$$

$$=(2Fm/\pi)\iint \left\{ \cos i \cos^2\phi \cos\psi + k \cos^3\phi \cos\psi \cos(\psi+i) \right\}\ d\psi\ d\phi$$

[3] See A. P. Trotter, Ill. Eng. (London) 12, 1919, p. 260.

$$= (2Fm/\pi) \left\{ \frac{\pi}{2} \cos i + k \frac{\pi}{3} \cos i \right\}$$

that the reflection factor is m $(1 + \frac{2}{3}k)$.

Jow if a surface of this kind is viewed in a constant direc- n AE making an angle ϵ with the surface, it is clear from . 2 that the brightness in this direction, due to the flux received the surface in the direction IA is, if the incident flux be per- tly diffused (*i. e.* of the same density F in all directions), resented by

$$F \cos i \, m(1 + k \sec i \cos \theta) \cos \phi \cos \psi \, d\psi \, d\phi$$
$$\text{where } \cos i = \cos \phi \cos \psi$$
$$\text{and} \quad \cos \theta = \cos \phi \cos (\psi - \epsilon).$$

t follows that the total brightness in the direction AE is

$$\int_0^{\frac{\pi}{2}} \int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} (Fm/\pi) \left\{ \cos^2\phi \cos \psi + k \cos^2\phi \cos (\psi - \epsilon) \right\} d\psi \, d\phi$$

$$= (2Fm/\pi) \left\{ \frac{\pi}{2} + k \frac{\pi}{2} \cos \epsilon \right\}$$

$$= Fm (1 + k \cos \epsilon).$$

extreme values for the brightness of the surface are thus in ratio of $1 : (1 + k)$ at glancing aspect and normal aspect ectively. The true value of the diffuse reflection factor of surface is, actually, the ratio of the total reflected to the l incident flux. The former is clearly

$$Fm \int_0^{\frac{\pi}{2}} (1 + k \cos \epsilon) \, 2\pi \sin \epsilon \cos \epsilon \, d\epsilon.$$

$$= \pi Fm \left(1 + \frac{2}{3} k \right)$$

le the incident flux is πF so that the value of ρ is m$(1 + \frac{2}{3}k)$ efore. This is the value obtained by a measurement of bright- s at the angle $\cos^{-1} (\frac{2}{3})$. A measurement of the normal htness gives a value of ρ which is in error by no less than per cent for the case when $k = 1$.[4]

[4] The consistency in the value of ρ obtained by Dr. Sharp and Mr. Little (*loc. cit.*) in case of polished opal glass is, presumably due to the fact that they made all their surements at the same value of ϵ.

In view of the very large errors given by the method in th case postulated, where the departure from perfect diffusion by no means extreme, it seems extraordinary that a correct resu should be obtained for a true mirror. Further consideratio *a priori,* however, shows that in this case, although at first sigh the surface behaves according to rule, in reality it does not do except when certain conditions, not usually taken into account a fulfilled. It is clear, for instance, that unless the *reflection fact of the mirror be the same for all angles of incidence of the ligh* different values of ρ will be obtained for different angles aspect and these will not, in general, be equal to the ratio the flux reflected to the flux incident on the surface.

It is interesting to note that the source of error just invest gated provides a complete explanation of the low values of refle tion factor obtained in the case of magnesium carbonate by th use of the Nutting reflectometer. It is not unreasonable to as sume that for this substance $f(i, \theta) = m(1 + 0.2 \sec i \cos \theta$ since this gives a reduction of brightness of only 5 per cent whe $\epsilon = 45°$ and the light is incident normally.[5] In this case th expression for B becomes

$$mF(1 + 0.2 \cos \epsilon)$$

$$\text{while } \rho = (1 + \frac{2}{15})m = 1.13m.$$

$$\text{If } \epsilon = 75° \qquad B = 1.05 \text{ mF}$$

so that the measured reflection factor is too small by about per cent and this is of the same order as the discrepancy actuall found.[6]

CONCLUSION

In measuring the diffuse reflection factor of any except perfectly diffusing surface it is necessary to ensure that th measurement made gives a correct value for the whole luminou flux reflected from the surface.

It is not justifiable to assume that the brightness of a surfac which is not perfectly diffusing is the same at all angles of vie when the illumination is diffused.

[5] See F. Thaler, *Ann. d. Phys.*, 11, 1903, p. 996.

[6] A. H. Taylor, Bureau of Standards, Bull. 16, 1920, p. 425.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK Meeting—April 19, 1923

The April meeting of the New York Section was held on Thursday afternoon, April 19, 1923, at five-thirty, in Room 2 of the Engineering Societies Building, 29 West 39th Street. The subject "The Application of Artificial Daylight to the Hospital Operating Room" was presented by Mr. Norman Macbeth of the Artificial Daylighting Company, New York City. A demonstration and display of daylighting luminaires was presented in conjunction with this talk. The Kny-Scheerer Corporation also displayed their operating room luminaire. This device showed the method of an auxiliary gas light which might be utilized in the event of any interruption in the electric service.

At five o'clock prior to the meeting a buffet luncheon was served to the members and guests. The time of the meeting was selected as a matter of experiment and judging from the size of the attendance of one hundred members and guests, the idea met with approval and will no doubt be tried at other section meetings.

CHICAGO Meeting—April 26, 1923

A noon-day meeting of the Chicago Section was held on April 26 and began with a luncheon at the Chicago Engineers' Club at twelve o'clock. Following the luncheon, the meeting was continued in the rooms of the Western Society of Engineers, where Mr. C. A. Atherton, National Lamp Works of Cleveland, delivered his paper, "Some New Ideas in Electric Sign Advertising," which was illustrated by means of lantern slides. The paper was very ably presented and was followed by an interesting discussion. The meeting adjourned at 3:15 P. M. There was an attendance of sixty members and guests.

PHILADELPHIA Meeting—April 10, 1923

At the meeting of the Philadelphia Section held at the Engineers' Club on April 10, Mr. G. Bertram Regar of the Philadelphia Electric Company presented a paper, "Selling the Idea of Better Lighting," which had been read before the convention of the Pennsylvania Electric Association by him last September. While primarily a central station subject the paper contained considerable material that was of interest to the lighting industry.

Mr. Regar compared the lighting load with the appliances and power load and stated that the former had not reached as high a standard as the latter. Electrical appliances have become a necessity in the home but the lighting installation is frequently subject to criticism. Poor lighting is not so much a matter of stinginess as it is poor planning and carelessness.

Lighting has three basic principles: First—*Utilization.* Successful business methods demand that the lighting be good, and good lighting is efficient, because the predominating factors have been treated in a scientific way. Second—*The Physiological Effect.* With the recognized advantages, both from the commercial and the industrial standpoints of a high intensity of illumination, if the eyes of our people are to be conserved, then careful consideration must be given the subject of proper direction, diffusion and color of lighting. Third—*Psychological Effect.* With the advancement of civilization, we have naturally been educated to the comforts and refinements of our present-day lives, and the artistic effect of lighting, therefore, plays a prominent part, as to whether it is pleasing or distasteful.

Mr. Regar then considered the aspects of residence and store lighting stating the characteristics which it should have and bringing out the places where improvements can frequently be made. Under the heading of industrial lighting he pointed out the necessity for insisting that this be sufficient not only to avoid accidents but to increase plant output.

In an appeal for better lighting the speaker stated that an intensive campaign for better lighting should be inaugurated; setting forth the arguments that good lighting brings about increased production, aids accident prevention, conservation of vision, improved aesthetic effects, happiness, health and many other advantages. It should be done nationally by articles in trade publications, and a concentrated effort by national advertisers. Automobile Associations should be asked to co-operate with a view of getting better highway lighting. State authorities should be asked to adopt school and factory lighting codes. City officials should be made to realize that good street lighting is a means of protection.

The paper was illustrated by lantern slides showing interiors of stores with examples of good and bad lighting. An interesting discussion was held and the meeting was attended by thirty members and guests.

MICHIGAN Meeting—May 7, 1923

The organization meeting of the new Michigan Chapter was held on the evening of May 7th in Detroit. Twenty-two members were present and a very gratifying interest was shown.

The following officers were elected: Chairman, James M. Ketch; Secretary-Treasurer, A. L. Lent; Messrs. Clarence Carson, H. H. Higbie, Ivan N. Kirlin, Harold Shaw and George Wagschal were elected to the Board of Managers.

After the regular business the probable activities of the new Chapter were discussed and they comprised such projects as State School, Industrial, and Headlighting Codes, Cooperation with Electrical Contractors, Architects and Consumers in the use of better lighting, and research standardization of special lighting problems in the automobile industry.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council, April 12, 1923, the following were elected to membership:

Four Members

GUNNISON, FOSTER, Cox, Nostrand & Gunnison, Inc., 337 Adams Street, Brooklyn, N. Y.
KILBY, KARL E., Coleman Lamp Co., 222 N. St. Francis Ave., Wichita, Kan.
KNIGHT, A. R., University of Illinois, Urbana, Ill.
WHEELER, HARRY E., 45 E. 55th St., New York, N. Y.

Twenty-Three Associate Members

ALEXANDER, L. M., University of Cincinnati, Cincinnati, Ohio.
BLACKMORE, CHARLES T., Stone & Webster, Inc., 147 Milk St., Boston, Mass.
CAMPBELL, CLARENCE J., Westinghouse Lamp Co., 165 Broadway, New York, N. Y.
CLARKE, FRANK A., Westinghouse Elec. & Mfg. Co., South Bend, Ind.
COBBY, E. V., Pacific Telephone & Telegraph Co., 807 Sheldon Bldg., San Francisco, Cal.
DOANE, FRANCIS H., International Correspondence Schools, Scranton, Pa.
DOLBIER, F. VAN BUREN, Philadelphia Electric Co., 132 S. 11th St., Philadelphia, Pa.
DOYLE, WALTER H., Central Hudson Gas & Electric Co., 129 Broadway, Newburgh, N. Y.
ENGELFRIED, HENRY O., Consolidated Elec. Lamp Co., 88 Holton St., Danvers, Mass.
HECKER, LOUIS M., Commercial Light Co., 127 N. Dearborn St., Chicago, Ill.
HERRMANN, W. S., Westinghouse Elec. & Mfg. Co., 1535 Sixth St., Detroit, Mich.
JAQUET, GEORGE E., Garden City Press, Gardenvale, Quebec, Canada.
KINSEY, FREDERICK S., Westinghouse Lamp Co., 165 Broadway, New York, N. Y.
LEWIS, FRANK L., Ivanhoe-Regent Works, G. E. Co., 108 S. 59th St., Philadelphia, Pa.
MARTIN, ALLEN J., 272 Engineering Bldg., University of Michigan, Ann Arbor, Mich.
MUDGETT, GUERNSEY F., Westinghouse Elec. & Mfg. Co., South Bend, Ind.
THOMPSON, H. R., Westinghouse Elec. & Mfg. Co., 515 Hanna Bldg., Cleveland, Ohio.
TRAWICK, SAMUEL W., JR., New Orleans Public Service, Inc., 201 Baronne St., New Orleans, La.

WEILER, EDWARD W., Edison Lamp Works, Harrison, N. J.
WEINER, PAUL S., Van Dyk & Reeves, Inc., 167-41st St., Brooklyn, N. Y.
WINETSKY, MICHAEL, Public Service Electric Co., 71 Murray St., Elizabeth, N. J.
WRIGHT, HOWARD L., National X-Ray Reflector Co., 750 Prospect Ave., Cleveland, Ohio.
ZIMMERMAN, J. HAROLD, Westinghouse Lamp Co., 165 Broadway, New York N. Y.

Two Sustaining Members

FRANKLIN ELECTRIC LIGHT CO., Avenue A, Turners Falls, Mass.
C. E. Bankwitz, Official Representative.
GAS & ELECTRIC IMPROVEMENT CO., 77 Franklin St., Boston, Mass.
Philip B. Jameson, Official Representative.

One Re-Election to Associate Membership

HALLOCK-GREENEWALT, MARY, 1424 Master St., Philadelphia, Pa.

Two Transfers to Full Membership

HANLAN, JAMES P., Public Service Gas Co., 80 Park Place, Newark, N. J.
LYON, HOWARD, Welsbach Co., Gloucester, N. J.

The General Secretary reported the death, on March 9, 1923 of one associate member, FRANK L. SAMPLE, National X-Ray Reflector Co., Boston, Mass.

CONFIRMATION OF APPOINTMENTS

As Chairman of the General Convention Committee—W. D'A. Ryan.

As members of the Committee on Membership—H. M. Camp and L. B. Johnson.

As an Advisory Committee to co-operate with the N. E. L. A. in arranging a course of instruction for men in lighting departments of various central stations—H. H. Higbie, Chairman; E. M. Alger, Earl Anderson, C. C. Munroe and T. W. Rolph.

NEWS ITEMS

BULLETIN OF THE COMMITTEE ON LIGHTING LEGISLATION

Massachusetts Industrial Lighting Code:

The Massachusetts Department of Labor and Industries has voted to adopt a lighting code for factories, workshops, manufacturing and mechanical establishments for the purpose of protecting employees from accidents and eye strain due to inadequate or faulty lighting. At present the code is not mandatory but the Labor Department has issued notice that the code will become mandatory on Jan. 1, 1924.

The Code is divided into two parts. Part I consists of six rules as llows: general requirements, intensity required, protection from glare—ading of lamps, distribution of light, entrance and exit lighting, classi-ation of intensity grades. Part II contains notes and recommendations.

Both Part I and Part II follow very closely the lines laid down the New York State code of lighting factories and merchantile estab-hments as amended May 1, 1922, except that in Part I the Massachusetts de contains an additional rule on entrance and exit lighting, based rtly on the exit and emergency lighting rule of the I. E. S. (American andard) Code, as follows:

Entrance and Exit Lighting: Lighting shall be provided in all stairways and exits of factories and in all the passageways appurtenant thereto, independent of the regular lighting of the working space. The lighting circuits for the stairways and exits should extend inside any working room where twenty or more persons are regularly employed, so as to light the immediate entrance to the stairway or exit. Such lights shall be served from a source not subject to failure because of the failure of the circuit fuses for the room lighting, and preferably from an independent connection extending back to the main service entrance for the building. In case unusual danger may exist on account of type of building, nature of the work, crowded conditions, or lack of suitable exit space, the Commissioner of Labor and Industries may require such lighting to be further extended within the working space; and that independent service shall be ensured by connection to a separate source of supply without or within the building.

The intensity rule of the Massachusetts code does not go as far that of the New York State code in that the former does not contain table of minimum intensities for detailed industrial operations and ocesses. On this point the Massachusetts code states that the "assign-ent of industrial operations (intensity grades) shall be determined by e Commissioner of Labor and Industries subject to review by the epartment upon application of anyone affected thereby."

The glare rule follows the same form as that used in the earlier ate codes and is open to the criticism of being too general. It is to be gretted that this rule was not made more specific to conform with the are rule in the I. E. S. code (American Standard).

In the preparation of the code the Department of Labor and Indus-ies had the assistance of a state committee of which Dr. Louis Bell as chairman. Dr. Bell also represented the I. E. S. Committee on ighting Legislation.

SECTIONAL COMMITTEE ON I. E. N. ORGANIZED

Thirteen men, consisting of six representatives of producers, thre representatives of consumers, and four representatives of general inter ests, constitute the personnel of the Sectional Committee on Illuminatin Engineering Nomenclature and Photometric Standards, one of the pro jects officially before the American Engineering Standards Committe

The Illuminating Engineering Society has been named sponsor fo this project. The men who constitute this committee, and the organiza tions which they represent, follow: American Gas Association, W. Serrill; American Institute of Electrical Engineers, A. E. Kennelly Bureau of Standards, A. S. McAllister; Illuminating Engineering Societ Howard Lyon and G. H. Stickney; National Committee of Internationa Commission on Illumination, Louis Bell; National Committee of Inter national Electrotechnical Commission, C. O. Mailloux; National Counc of Lighting Fixture Manufacturers, E. C. McKinnie; National Electri Light Association, C. H. Sharp; Optical Society of America, E. C. Crit tenden; American Physical Society, E. P. Hyde; Individuals, G. A. Hoad ley and M. Luckiesh.

STANDARDIZATION OF TRAFFIC SIGNAL COLORS

Forty-two men, representing the manufacturers and users of traffi signals, federal and state governmental departments, associations inter ested in the prevention of traffic accidents, and representatives of th general public, are now at work on the drafting of a national code o the proper colors for traffic signals, which it is expected will not only cu down the annual loss of life through traffic accidents, but will eliminat many of the existing irritations to motorists and to the operators o steam and electric railways.

This work is being carried on under the auspices of the America Engineering Standards Committee whose approval of a code or standar insures its ultimate acceptance and observance throughout the country The American Engineering Standards Committee is composed of seve departments of the U. S. Government, the principal technical, industria and engineering societies and individual business concerns interested i standardization.

The sectional committee drafting this code is made up of seve representatives of the manufacturers of traffic signals, nine representa tives of the purchasers of such equipment, three representatives of th users of traffic signals, twelve representatives of governmental bodie five technical specialists, and six insurance representatives.

Mr. Charles J. Bennett, State Highway Commissioner of Connecti cut, who represents the American Association of State Highway Officials has been selected chairman of the sectional committee. Dr. M. G. Lloyd of the U. S. Bureau of Standards, who is the representative of both th Bureau and the American Society of Safety Engineers, is vice-chairman and Mr. Walter S. Paine, Research Engineer of the Aetna Life Insuranc

o., who is the representative of the National Safety Council is secretary : the sectional committee.

PLAN BETTER LIGHTING IN SCHOOLS TO SAVE THE EYES OF YOUTH

The lighting, building, education, health, and social agencies of the untry have joined hands in an effort to develop a nationally accepted de for school lighting which will correct the conditions partially responble for the defective vision of 10 to 20 per cent of the school children.

The formulation of this code is being carried on under the auspices the American Engineering Standards Committee, a federation of tional organizations, government departments, and other agencies interted in standardization, whose official approval of a standard or code sures its ultimate acceptance by the principal interests concerned.

The conditions that make such a code necessary have been summarized follows by a committee of the Illuminating Engineering Society:

"Examinations of thousands of school children, extending over many ars, have shown that from 10 to 20 per cent of the children suffer om defective vision, the result largely of continued use of the eyes in ose work under unhygienic conditions. It is well established that defece vision is progressive and is therefore found to a larger extent among e older children.

"Many of the factors contributing to defective vision of children e closely connected with school life, and to this extent the causes are pentable and may be removed. Modern educational methods impose vere requirements upon the immature eyes of children and create the ed for the very best working conditions.

"It is therefore essential that the lighting of school buildings, both tural and artificial, should be of the best design. The status of the art illumination is so well established that it is entirely feasible and practible to prevent eye-strain by the proper design of school buildings and e installation of suitable lighting equipment.

"Economically, it is found that, in general, children with defective sion are retarded in their progress in school life, and also enter upon their e work seriously handicapped. It is right, therefore, that a state should ncern itself to protect and conserve the vision of children from an onomical, as well as a humanitarian standpoint."

The American Engineering Standards Committee has appointed the merican Institute of Architects and the Illuminating Engineering Society nt sponsors for the code on school lighting. The sponsors will organize representative sectional committee to formulate the code and will prole for the publication of the code after it has been approved by the E. S. C.

The organizations that are already co-operating in this work are: merican Gas Association, American Institute of Architects, American

Institute of Electrical Engineers, American Public Health Associati American Society of Safety Engineers, American Medical Associati Illuminating Engineering Society, National Committee for the Preve tion of Blindness, National Bureau of Casualty and Surety Underwrite National Education Association, U. S. Bureau of Education, Departm of Interior, U. S. Public Health Service, Treasury Department, U. Women's Bureau, Department of Labor, U. S. Bureau of Standards.

GRAND ILLUMINATION AT WASHINGTON PLANNED FOR MYSTIC SHRINERS

Brilliant illumination and showers of light will flood the cap city during the entertainment of more than 300,000 Shriners who will co from all parts of the United States to Washington in June. A Gar of Allah will be erected in front of the White House, and a blaze of li will usher in the street pageant of the Masons. Committees of el tricians are now working out the details for the gala electrical effects.

Many special electrical settings will be installed upon the wide e lined avenues of the nation's official headquarters, and the parade costumed Shriners, uniformed patrols, bands, and dignitaries will p through a flood of light.

Pennsylvania avenue, down whose historic lanes Presidents h ridden to attend their own inaugural ceremonies for many generati and whose wide street spreads toward the Capitol, lit by batteries searchlights, will be brilliantly illuminated for this convention.

CONVENTION PAPER INCREASES WINDOW LIGHTING

It is very gratifying to note how the disinterested work of I. E. S. is helping to increase the lighting load of the central stations. following reference to the Sturrock-Shute paper presented at the convention in Swampscott appeared in the *Electrical World* of April 1923.

> "The connected load in window lighting of a large departm store served by the Fitchburg (Mass.) Gas and Electric Light C pany was increased nearly 200 per cent as a result of presenting customer with a paper on show-window lighting which was at the last convention of the Illuminating Engineering Soc After offering the paper to the customer for perusal, the cent station sales department and the department store's window dec tor conducted a series of tests which proved to the user's satis tion that it would pay to use a higher intensity in his windows had formerly been employed."

1923 CONVENTION AT LAKE GEORGE

At recent meetings of the Council the time and place of the Seven-enth Annual Convention of the Illuminating Engineering Society have en decided, and members of the 1923 Convention Committee have been pointed. The convention headquarters will be at the Fort William enry Hotel at Lake George, N. Y., and September 24 to 28 are the days osen. The activities of the committee are in charge of the following: r. W. D'A. Ryan, Chairman; Mr. H. W. Peck, Vice-Chairman; and Mr. E. Mahan, Secretary.

Plans are now being formulated and full publicity will be given to members of the Society, and present indications point to a very suc-ssful convention. It is hoped that a large number of the members will serve these dates and make every effort to attend the convention.

THE MEMBERSHIP DRIVE

Under the able leadership of Mr. G. Bertram Regar, Vice-President, membership drive for the past eight months has been the most suc-ssful in the history of the Society. Reference to the Society Affairs the TRANSACTIONS will show that nearly two hundred new members ve been elected.

The splendid work already accomplished can be greatly aided by a of *personal effort* on the part of *each individual member.* There must men among your associates who should be members in the I. E. S. ke up this challenge and send to the chairman of the committee names prospective applicants; or, better still, send the signed application with eck for entrance fee and current dues. Applicants for the grade of *sociate member* for the balance of the fiscal year should remit $3.75 dues and $2.50 for entrance fee; for the grade of *member,* $7.50 for es and $2.50 for entrance fee.

Application blanks and membership literature can be secured from mbers of the committee or from the General Office.

CHICAGO ELECTRICIANS' APPRENTICES COURSE

A series of talks under the supervision of Mr. J. L. Stair, National Ray Reflector Company, was given during the latter part of March fore apprentice classes consisting of six hundred construction elec-cians and stage electricians at the Washbourne Continuation School, icago.

The apprentices are required by their Unions to attend school one y out of every two weeks for which they receive regular pay from eir employer. The course continues for four years, and after the urse is over, the apprentices are required to take examinations to be-me journeymen and receive cards from the Local Union.

In the series of talks, historical facts concerning the development of ificial lighting were presented, together with some of the fundamental nciples in lighting practice, and examples of modern installations. The bject was treated in a purely educational way with demonstrations and itern slides.

PERSONALS

Mr. J. L. Wolf, formerly secretary of the Lighting Fixture Deale Society of America, and secretary of the Cleveland Electrical Leag is now in the retail fixture business as the Wolf Lighting Company.

Mr. George H. Stickney, Past-President of the I. E. S., has recen been honored by an election to membership in the Alpha Chapter of Sigma Xi fraternity at Cornell University. Mr. Stickney has been ider fied with work in illuminating engineering since his graduation fr Cornell in 1896.

SUGGESTIONS TO AUTHORS OF PAPERS

For

PRESENTATION AT THE ANNUAL CONVENTION

Final Acceptance Date

The manuscripts of papers to be preprinted for the Annual Convention must be in New York by *August 1* if authors wish to see proof before publication. Papers will be accepted from this date until *August 15*, but no proofs of them will be submitted to the authors for approval.

Synopsis

A short synopsis (200 words or less) should accompany each paper. This is required for publication with the paper and also for publication in advance notices of the convention.

Illustrations

All illustrations for half tone cuts should be submitted as original photographs upon glossy paper.

Diagrams should be drawn upon white paper, or blue cross-section paper which will be supplied by the Committee upon request. Blue lines upon the cross-section paper do not reproduce photographically and, therefore, all lines which are to be shown in the finished graph should be inked in. Blue prints and photostat prints do not make good cuts.

Captions and descriptive matter should be typewritten and attached to the photographs or diagrams.

Lettering upon the face of the diagram should be as simple as possible, and large enough to reproduce when the diagram is photographed and reduced to one-quarter size.

Copyright

Papers presented before the Society are considered to be the property of the Society and are copyrighted upon publication in the Society's TRANSACTIONS. Permission may be given by the Committee to reprint any paper in part or in full subsequent to presentation provided proper credit is given to the author and to the Society.

ILLUMINATING ENGINEERING SOCIETY
Committee on Editing and Publication,
29 West 39th Street, New York, N. Y.

LLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

ı INDEX OF REFERENCES to books, papers, editorials, news and abstracts on ıating engineering and allied subjects. This index is arranged alphabetically ing to the names of the reference publications. The references are then in order of the date of publication. Important references not appearing should be called to the attention of the Illuminating Engineering Society, 39th St., New York, N. Y.

	AUTHOR	DATE	PAGE
an Elevator and Grain Trade			
ghting of Grain Elevators—	W. H. Rademacher and E. L. Dee	1922 Dec. 15	402
an Miller			
ghting of Flour Mills—	W. H. Rademacher and E. L. Dee	Dec. 1	1246
an Journal of Physiological Optics		1922	
mit of Visibility in the Ultra-Violet	A. E. Glancy	April	145
ıe Absorption of the Eye for Ultra-Violet Radiation—	W. P. Graham	April	152
an Journal of Physiology			
udies on the Relative Physiological Value of Spectral Lights—III—The Pupillomotor Effects of Wave-Lengths of Equal Energy Content—	H. Laurens	1923 Mar. 1	97
ıe Relative Stimulating Efficiency of Continuous and Intermittent Light in the Tachina Fly, Archytas Aterrima—	W. L. Dolley, Jr.	Apr. 1	364
can Journal of Psychology			
Case of Color Blindness to Yellow and to Blue—	F. R. Robinson	April	157
he Effect of Intensity of Illumination on the Acuity of the Normal Eye and Eyes Slightly Defective as to Refraction—	C. E. Ferree and G. Rand	April	244
osition vs. Intensity as a Determinant of Clearness—	K. M. Dallenbach	April	282
isual Intensity—		April	310

American Journal of Science		
Phosphorescence and Luminescence in Calcites—	W. P. Headden	April
Annalen der Physik		
Uber die Schwachung der sichtbaren Strahlung durch künstlichen homogenen Nebel—	O. Werner	Mar. 20
Berichte der deutschen chemischen Gesellschaft		
Die Einwerkung des Sonnenlichtes auf die Zimtsäuren und die Salze der trans-Zimsäure—		Apr. 11
Biochemische Zeitschrift		
Fermente und Licht, I— II—	L. Pincussen and N. Kato	Jan. 16
Central Station		
The Glassteel Diffusers—	Ward Harrison and J. W. Waterbury	April
Proper Use of Mill-Type Lamps—	James M. Ketch	April
Chemical Abstracts		
Summary of the Progress Made to Date by Various Investigators in an Effort to Standardize Methods for Determining the Fastness of Dyes to Light—	W. H. Cady	Feb. 20
Artificial Daylight (for Color Matching)—	F. E. Lamplough	Mar. 10
Color Matching as a Factor in Accurately Rating the Relative Values of Dyestuffs—	H. S. Busby	Mar. 20
The Action of Light on Paint Materials—V. Causes and Elimination of the Non-Sunproofness of Lithopone—	A. Eibner	Apr. 10
Naming and Defining the Fastness to Light of Printing Inks—	Martin Hartmann	Apr. 10
Comptes Rendus		
Application de la photographie a l'etude de l'opalescence critique—	A. Andant	Feb. 12
Etude spectrale de la triboluminescence de quelques corps—	H. Longchambon	Mar. 5

y World			
ghting Systems in the Retail Store		Jan.	39
olor Lighting in the Show Window		Jan.	22
ic Railway Journal			
gnal Maintenance on an Oregon Railway—	H. J. Charters	Mar. 17	468
ical Merchandising			
ne Decorative Idea in Wiring—		April	3245
ical News			
curing Efficiency in Residential Illumination—III—	W. H. Rademacher	Mar. 15	49
curing Efficiency in Residential Illumination—IV—	W. H. Rademacher	Apr. 1	46
ical Record			
Guide for Good Theater Lighting—	A. L. Powell	Mar.	142
me Practical Suggestions for the Lighting of Concert Halls—	A. L. Powell	Mar.	181
Well Lighted Printing Plant Offers Visual Speed and Accuracy—	R. A. Palmer	Mar.	181
New Model of Lightmeter for Field Work—		Mar.	182
Lighting Installation of High Intensity for Auditoriums—		Mar.	182
ghting System Installed to Give Varied Intensity—		Mar.	183
lectrifying the Garment Industries—		April	212
hite Ways for Business Districts—	S. B. Williams	April	216
age Lighting Equipment and Its Application—	A. L. Powell	April	233
ecommended Practice for the Lighting of Canneries and Packing Houses—		April	246
ow to Eliminate the Sharp Shadows	J. M. Shute	April	247
lumination Tests of Pittsburgh Department Store Show Interesting Figures—		April	248
lan National Code for Better Lighting in Schools—		May	269
ome Local Lighting Problems in an Industrial Plant—	A. R. Herske	May	314
nforcement of Industrial Lighting Codes Shows Results—		May	314

Daylight Quality and True Retinal Brilliancy Sought in Unit—	F. W. Mathieu	May
Increase in Illumination Results in Increased Production of Coal—		May
Recent Installations of Lighting Equipment to Give Tone and Character to Establishment—		May

Electrical Review

Modern Stage Lighting—II—		Mar. 23
Stimulating Growth by Light—		Mar. 30
The Illumination of Automobile Showrooms—		Apr. 13

Electrical Times

A Street-Lighting Problem (Notes on the Lighting of the Great Western Road, Glasgow, and the Question of Central Pillars)—		Mar. 8
When is Light not Light?—		Mar. 29
When is Light not Light?—		Apr. 12
Light Without Heat—		Apr. 5

Electrical World

Lansing to Have Architecturally Uniform Lighting System—	O. E. Bulkeley	Mar. 3
The Technique of Post Office Illumination—		Mar. 24
Illumination of Post Offices—		Mar. 24
Nomographic Chart for Designing Illumination—	Emil Kun	Apr. 7
Editorial—		
Relative Effectiveness of Direct and Indirect Illumination—		Apr. 28
Report on Post Office Illumination Criticized—		Apr. 28

Electrician

Modern Requirements in Street Lighting—		Dec. 29
Electric Lamps in Mines—		Dec. 29
Electric Lighting and Education—	G. Benoit	Mar. 30
The Planning of Daylight Illumination		Apr. 13

L'Electricien

L'Eclairage electrique des trains; le systeme Rosenberg—	P. Bougrier	Feb. 15

rotechnische Anzeiger			
eleuchtung und Steigerung der Erzeugung in Metal bearbeitungsbetrieben—		Jan. 31	132
ie Notbeleuchtung in Theatern und Warenhäusern—		Mar. 1	255
ie Zeitgemässe Reklamebeleuchtung—		Mar. 6	273
rotechnische Zeitschrift			
/erkplatzlampen—		Mar. 15	244
eering Progress			
actory Lighting—			
ry	H. Lux	Jan.	8
etter Ways to Light the Work—			
ournal		Mar.	366
. Study of Lighting Burners—			
llectric Light and Eyesight—		Feb. 28	510
treet Lighting—		Feb. 28	514
he Microscope in the Mantle Industry—		Mar. 21	745
as Lighting—		Mar. 21	751
n Efficiency Department and Indoor Lighting—		Mar. 21	759
ummer Time—		Apr. 11	85
ur Lighting Load (Gas Lighting Maintenance)—		Apr. 11	89
he Study of Daylight Illumination—	E. E. Stones	Apr. 11	95
		Apr. 11	103
nd Wasserfach			
egenwart und Zukunft der Gasbeleuchtung—	Karl Bunte	Feb. 24	113
al Electric Review			
tudies in the Projection of Light—II—	F. A. Benford	Mar.	160
tudies in the Projection of Light—Part III—	F. A. Benford	Apr.	230
Part IV—		May	280
inating Engineer		1922	
olor, Loss of, in Objects Exposed to Light—		Nov.-Dec.	308
rogress in Illuminating Engineering—		Nov.-Dec.	291
he Position of the Metal Filament Lamp and Fittings Industry at the Present Time—		Nov.-Dec.	299
ew Types of Hospital Inspection Lamps—		Nov.-Dec.	302

Lighting at the Port of London Building—		Nov.-Dec.
Impregnated Silk Shades—		Nov.-Dec.
Industrial Lighting—		Nov.-Dec.
Light, Effect on the Constitution of the Blood—		Nov.-Dec.
Exterior Lighting with Acetylene Flares		Nov.-Dec.
Industrial and Engineering Chemistry		1923
Determination of Small Quantities of Molybdenum in Tungsten—	W. J. King	Apr. 1
Journal of the American Institute of Electrical Engineers		
Massachusetts Starts Enforcement of Tail-Light Laws—		April
Capitol of Michigan Will Have First Architecturally Uniform Lighting System—	O. E. Bulkeley	April
Journal of the Chemical Society		
Tesla-Luminescence Spectra—Part I. The Form of Apparatus and the Spectrum of Benzene—	W. H. McVickers, J. K. Marsh and A. W. Stewart	Mar.
Journal of Electricity and Western Industry		
Street Lighting During Past Year—		Mar. 1
Stimulate the Demand for Ornamental Street Lamp Installation—		Mar. 1
Journal of Experimental Psychology		
The Relation Between Field Brightness and the Speed of Retinal Impression—	P. W. Cobb	April
Journal of General Physiology		
Circus Movements of Limulus and the Tropism Theory—	W. H. Cole	Mar. 20
Journal of the Optical Society		
An Optical Altitude Indicator for Night Landing—	J. A. C. Warner	Mar.
A Color-Match Photometer for Illuminants—	H. E. Ives	Mar.
Simultaneous Color Measurements by Trichromatic and Monochromatic Analysis—	H. E. Ives	April

nal of Physical Chemistry

Structural Colors in Feathers, I—	C. W. Mason	Mar.	201
Production and Characteristics of the Carbides of Tungsten—	Mary R. Andrews	Mar.	270

nal of Washington Academy of Sciences

The Measurement of Light—	E. C. Crittenden	Mar. 4	69

: und Lampe

Das Licht der für die Therapie in Frage kommenden Lichtquellen—	Fritz Schanz	Jan. 18	31
Über die Qualität des Leuchtgeräts—	H. Müller	Jan. 18	35
Über eine Lichtquelle von sehr hoher Flachenhelligkeit—	Gerdien and Lotz	Jan. 18	37
Über den Wert des Tageslichtquotienten für die hygienische Beurteilung der Lichtgüte eines Arbeitsplatzes—		Feb. 1	57
Beleuchtung von Operationssählen—	H. Lux	Feb. 1	58
Über einige Anwendungen des Lichtstrompapieres in der Beleuchtungstechnik—	A. A. Wohlauer	Feb. 1	60
Kirchenbeleuchtung—		Feb. 15	81
Kirchenbeleuchtung—	H. Lux	Mar.	109
Die Beleuchtungsindustrie auf der Leipziger Frühjahrsmesse—	K. Weiss	Mar. 15	138
Die Beleuchtung der Philharmonie in Berlin—	O. Gerhardt	Mar. 15	141
Verband der Beleuchtungs-Grosshändler E. V., Sitz Berlin Vollversammlung in Leipzig—		Mar. 15	143

ting Fixtures and Lighting

Lighting for Public Eating Places Individual—		Mar.	16
Steamship Leviathan Lighting Equipment Luxurious—		April	13
Opposes Elimination of Word "Fixture"		April	15

thly Weather Review 1922

Daylight Illumination on Horizontal, Vertical and Sloping Surfaces—	H. H. Kimball and I. F. Hand	Dec.	615

Motion Picture		1923
Fundamentals of Light for Understanding of Cinematography—		Feb. 24 Mar. 24
Motion Picture News		
Incandescent Lamp Projection is now Perfected—		Feb. 10
N. E. L. A. Bulletin		
Residence Lighting—II. Brief Lighting Recipes for the Home—	M. Luckiesh	Mar.
National Physical Laboratory Report for 1921		
Photometry—		
National Research Council—Bulletin		1922
The Present Status of Visual Science	L. T. Troland	Dec.
National Research Council of Japan—Japanese Journal of Physics		
A Fluorescing Substance in Mandarin Orange Peel—	M. Kimura and G. Nakamura	Vol. 1, 5 &
Pflüger Archiv für Ophthalmologie		1923
Messende Untersuchungen über das Purkingesche Phänomen in Nachbilde—	M. H. Fischer	Mar. 15
Philosophical Magazine		
On the Production of Colored Flames for Use with Spectrometers and Polarimeters—	J. J. Manley	Feb.
On the Molecular Scattering and Extinction of Light in Liquids and the Determination of the Avogadro Constant—	C. V. Raman and K. Seshagiri Rao	Mar.
The Fluorization and Colorization of Glass Produced by β-rays—	J. R. Clarke	Apr.
Photographic Journal of America		
New Method of Illumination in Photomicrography—		Mar.
Strength of Light Source (for Photography)—		Mar.

ical Review

Luminescence of Organo-Magnesium Halides—	R. T. Dufford S. Calvert and D. Nightingale	Feb.	203
The Low Voltage Mercury Arc—	M. Scott	Feb.	204
The Luminous Electricical Discharge in Sodium Vapor—	G. M. J. MacKay and E. E. Charlton	Feb.	209
The Luminous Efficiency of Gases Excited by Electric Discharge—	A. H. Compton and C. C. VanVoorhis	Feb.	210
Photo-Electric Cells with Hot Filaments—	J. Tykocinski-Tykociner and Jakob Kunz	Feb.	210
The Photo-Electrical Properties of Heated Oxides—	H. Kahler	Feb.	213
The Photo-Electrical Properties of the Phosphors—	H. Kahler	Feb.	214
Theory of the Electric Arc—	K. T. Compton	Mar.	266
Evaporization Characteristics of Tungsten—	G. R. Fonda	Mar.	343
The Photo-Electromotive Effect in Selenium—	E. H. Kennard and C. Moon	Mar.	374
Variation of Capacity of Photo-Electric Cells with Illumination—	J. Tykocinski-Tycociner	Mar.	383

sikalische Zeitschrift

Über die Anwendung einer Beleuchtungsazimutblende bei koaxialer Dunkelfeldbeleuchtung—	A. Szegvari	Feb. 15	91
Färbung rotierender Scheiben bei doppolter Beleuchtung—	A. Steichen	Mar. 1	112

ular Mechanics Magazine

Adjustable Automobile Headlight Eliminates Glare—		Mar.	392
Motion Picture Projectors Tested in Tunnel—		Mar.	383
"Vacuum Tube" Signs Yield Light at Small Cost—		Mar.	361

lic Works

Municipal Lighting in Los Angeles—		Apr.	135

Railway Electrical Engineer		
Car Lighting Maintenance Methods on the Erie—		Mar.
Railway Signal Engineer		
Manufacture of Incandescent Lamps—		Feb.
Revue d'Optique		
Sur quelques proprietes des sources lumineuses a rayonnement integral	A. Boutaric and M. Vuillaume	Feb.
Revue Generale de l'Electricite		
Comite national francais de l'eclairage		Feb. 10
Bougie decimale et bougie Hefner—		Feb. 17
L'Arc electrique—	M. Leblanc	Feb. 24
Reduction des variations de l'intensite lumineuse des lamps a incandescence par l' emploi de resistances en fil de fer en serie—		Mar. 24
Etude de l'influence de la temperature sur la marche de la decharge dans les gaz rarefies—		Mar. 31
Safety Engineering		
Good Lighting Reduces Accidents and Losses—	A. E. Johnson	Jan.
Science		
The Eyesight Conservation Council of America—		Mar. 30
On the Formation of Organic Compounds from Inorganic by the Influence of Light—	Oskar Baudisch	Apr. 20
On the Spectral Characteristics of Protective Coloration—	C. M. Sparrow	Apr. 27
The Minimum Concentration of Luciferin to Give a Visible Luminescence—	E. N. Harvey	Apr. 27
Science Abstracts—A		
Discussion on the Horizontal Range of Vision as a Meteorological Observation—	F. J. W. Whipple	Feb. 25
Science News-Letter		
Attack Street Lights as Grossly Inefficient		Mar. 10
New Element Isolated May Aid Gas Mantles—		Mar. 10
Close to Absolute Zero Record Cold Achieved—		Apr. 7

tific American			
he Detection of Cultivated Japanese Pearls—		April	227
of the Times			
amp Spacing for Exposed Lamp Electric Signs—	C. A. Atherton	April	45
ngsberichte, Wien			
)ie Verteilung der Helligkeit auf der Sonnenscheibe und die Temperaturschichtung in der Sonnenatmosphäre—	R. Dietzins	No. 1 (1922)	15
)ie Photometrie der Quecksilberquarzlampe mit Bezug auf die Messung der Lichtstrahlen-Dosen in der Therapie—	J. M. Eder	No. 1 (1922)	37
Jber die Abhängigkeit der Lichtstärke der Hefnerlampe vom Luftdrucke—	A. Boltzmann and A. Basch	No. 1 (1922)	57
sactions of the Illuminating Engineer- ; Society			
Vindowless Museums Forecast for Future—		Mar.	237
,ighthouses and Light Vessels—	S. G. Hibben	Mar.	241
\ Distribution Photometer of New Design—	C. C. Colby and C. M. Doolittle	Mar.	273
The Regular Icosahedron as a Substitute for the Ulbricht Sphere—	K. S. Weaver and B. E. Shackleford	Mar.	290
Opportunity for International Co-operation on Technical Matters—	E. C. Crittenden	April	323
Artificial Light and Our Eyes—	Elmer A. Sperry	April	325
Street Lighting Problems in 1823—		April	329
Lamp-Socket Standardization—		April	330
Determination of Reflection Factor Surfaces—	W. F. Little	April	333
The Influence of Paint on Interior Illumination—	R. L. Hallett	April	338
Paint Characteristics and Conditions to be Considered in Effecting Better Illumination—	C. H. Bryce	April	347
Paint as an Aid to Illumination from the Machinery Painting Angle—	L. E. Jamme	April	355
Illuminating Flares—	G. J. Schladt	April	366

Zeitschrift für Physik		
Die Anode des Quecksilberlichtbogens	A. Günther-Schultze	Feb. 26
Über die lichtelektrische Empfindlichkeit von wasserstoffbeladenen Palladium-Silberlegierungen—	F. Kruger and A. Ehmer	Mar. 5
Über eine Leuchterscheinung an Wolframanoden—	Marin Katalinic	Mar. 5
Über Kathoden-und Anoden im Hg-, Zn-, Cd- und Mg-Vakuumlichtbogen—	H. Schuler	Mar. 5
Zeitschrift für Technische Physik		
Lumineszenzerscheinungen und ihre Beziehungen zur Technik—	F. Schroter	Jan.
Über die Abhangigkeit der Lichtstarke der Hefnerlampe vom Luftdrucke—	A. Blotzmann and A. Basch	Jan.
Über die Temperatur der Krater einiger Bogenlampenkohlen und die Strahlung des Flammenbogens zwischen ihnen—	F. Patzelt	Feb.

OFFICERS & COUNCIL

1922-23

President

WARD HARRISON,
Nela Park,
Cleveland, Ohio
Term expires Sept. 30, 1923

Junior Past Presidents

GEO. H. HARRIES,
208 South LaSalle Street,
Chicago, Ill.
Term expires Sept. 30, 1923

GEO. S. CRAMPTON,
1819 Walnut Street,
Philadelphia, Pa.
Term expires Sept. 30, 1924

Vice-Presidents

F. M. FEIKER,
36th Street and 10th Avenue,
New York, N. Y.
Term expires Sept. 30, 1923

O. L. JOHNSON,
53 W. Jackson Blvd..
Chicago, Ill.
Term expires Sept. 30, 1924

WM. J. DRISKO,
Mass. Inst. of Technology,
Cambridge, Mass.
Term expires Sept. 30, 1924

G. BERTRAM REGAR,
1000 Chestnut Street,
Philadelphia, Pa.
Term expires Sept. 30, 1924

General Secretary

SAMUEL G. HIBBEN,
165 Broadway,
New York, N. Y.
Term expires Sept. 30, 1923

Treasurer

L. B. MARKS,
103 Park Avenue,
New York, N. Y.
Term expires Sept. 30, 1923

Directors

Terms expire Sept. 30, 1923

WALTON FORSTALL,
1401 Arch Street,
Philadelphia, Pa.

ADOLPH HERTZ,
Irving Place and 15th Street,
New York, N. Y.

FRANK S. PRICE,
160 Pearl Street,
Boston, Mass.

Terms expire Sept. 30, 1924

F. C. CALDWELL,
Ohio State University,
Columbus, Ohio

AUGUSTUS D. CURTIS,
235 W. Jackson Blvd.,
Chicago, Ill.

Preston S. MILLAR,
80th St. and East End Ave.,
New York, N. Y.

Terms expire Sept. 30, 1925

FRANK R. BARNITZ,
130 East 15th St.,
New York, N. Y.

CLARENCE L. LAW,
Irving Place and 15th Street
New York, N. Y.

A. L. POWELL,
Fifth and Sussex Sts.,
Harrison, N. J.

SECTION & CHAPTER OFFICERS

Chicago Section

CHAIRMAN . . . . Albert L. Arenberg, 316 S. Wells St., Chicago, Ill.
SECRETARY . . . . F. A. Rogers, Lewis Institute, Madison and Robey Sts., Chicago, Ill.

MANAGERS

J. H. Allen . . . . Monadnock Block, Chicago, Ill.
F. A. DeLay . . . . 72 W. Adams St., Chicago, Ill.
F. Lee Farmer . . . . 216 S. Jefferson St., Chicago, Ill.
W. M. Goodrich . . . . 500 South Clinton St., Chicago, Ill.
J. J. Kirk . . . . 72 W. Adams St., Chicago, Ill.

New England Section

CHAIRMAN . . . . R. R. Burnham, 119 Water St., Boston. Mass.
SECRETARY . . . . J. Daniels, 39 Boylston Street, Boston, Mass.

MANAGERS

W. V. Batson . . . . 210 South Street, Boston, Mass.
Francis A. Gallagher . . . . 814 Turks Head Bldg., Providence. R. I.
J. A. Toohey . . . . Box 3396, Boston, Mass.
L. T. Troland . . . . Harvard Univ., Cambridge, Mass.
J. L. Tudbury . . . . 247 Essex Street, Salem, Mass.

New York Section

CHAIRMAN . . . . A. L. Powell, Edison Lamp Works, Harrison, N. J.
SECRETARY . . . . J. E. Buckley, Irving Place and 15th Street, New York, N. Y.

MANAGERS

R. B. Burton . . . . 6 W. 48th Street, New York, N. Y.
J. R. Fenniman . . . . 130 E. 15th Street, New York, N. Y.
A. M. Perry . . . . 10th Ave. and 36th Street, New York, N. Y.
H. A. Sinclair . . . . 526 W. 34th Street, New York N. Y.
Geo. Strahan . . . . 507 W. 24th Street, New York, N. Y.

Philadelphia Section

CHAIRMAN . . . . Howard Lyon, Welsbach Co., Gloucester, N. J.
SECRETARY . . . . H. Calvert, 2114 Sansom Street, Philadelphia, Pa.

MANAGERS

H. B. Andersen . . . . 20 Maplewood Ave., Philadelphia, Pa.
C. E. Clewell . . . . Univ. of Penn., Philadelphia, Pa.
M. C. Huse . . . . 1000 Chestnut Street, Philadelphia, Pa.
J. B. Kelley . . . . 235 Market Street, Philadelphia, Pa.
W. E. Saunders . . . . Broad and Arch Sts., Philadelphia, Pa.

Cleveland Chapter

CHAIRMAN . . . . C. L. Dows, Nela Park, Cleveland, Ohio
SECRETARY . . . . E. W. Commery, Nela Park, Cleveland, Ohio

San Francisco Bay Cities Chapter

CHAIRMAN . . . . Leonard E. Voyer, Rialto Bldg., San Francisco, Calif.
TREASURER . . . . J. A. Vandegrift, 1648 16th Street, Oakland, Calif.

Toronto Chapter

CHAIRMAN . . . . G. R. Anderson, Univ. of Toronto, Toronto, Canada
SECRETARY-TREASURER . . . . M. B. Hastings, 62 Front St. W., Toronto, Canada

Northern New Jersey Chapter

CHAIRMAN . . . . W. T. Blackwell, 80 Park Place, Newark, N. J.
SECRETARY . . . . H. C. Calahan, 14 Mechanic Street, Newark, N. J.
TREASURER . . . . George E. Davis, 15 Central Ave., Newark, N. J.

Columbus Chapter

CHAIRMAN . . . . G. F. Evans, 162 West Long Street, Columbus, Ohio
SECRETARY . . . . R. C. Moore, 146 North Third Street, Columbus, Ohio

Michigan Chapter

CHAIRMAN . . . . James M. Ketch, 2000 Second Ave., Detroit, Mich.
SECRETARY-TREASURER . . . . A. L. Lent, 2000 Second Ave., Detroit, Mich.

CALIFORNIA:	San Francisco	Romaine W. Myers, 204 Bacon Building, Oakland.
	Los Angeles	F. S. Mills, 631 Pacific Finance Building.
COLORADO:	Denver	G. O. Hodgson, Edison Lamp Works.
CONNECTICUT:	New Haven	Charles F. Scott, Yale University. J. Arnold Norcross, 80 Crown Street.
	Hartford	R. E. Simpson, Travelers Insurance Co.
DISTRICT OF COLUMBIA:	Washington	R. B. Patterson, 213 14th Street. E. C. Crittenden Bureau of Standards.
GEORGIA:	Atlanta	Charles A. Collier, Electric and Gas Building.
IDAHO:	Boise	W. R. Putnam, Idaho Power Co.
KENTUCKY:	Louisville	H. B. Heyburn, Second and Washington Sts.
LOUISIANA:	New Orleans	Douglas Anderson, Tulane University of Louisiana.
MASSACHUSETTS:	Springfield	J. F. Murray, United Electric Light Co.
	Worcester	Carl D. Knight, Worcester Polytechnic Institute.
MICHIGAN:	Detroit	F. R. Mistersky, 129 Kenilworth Avenue. Charles Monroe, Detroit Edison Co.
MINNESOTA:	St. Paul	A. L. Abbott, 174 E. 6th Street.
	Minneapolis	G. D. Shepardson, University of Minnesota.
MISSOURI:	St. Louis	Louis D. Moore, 1130 Railway Exchange Bldg
NEW YORK:	Rochester	Frank C. Taylor, 166 Shepard St.
	Schenectady	S. H. Blake, General Electric Co.
OHIO:	Cincinnati	A. M. Wilson, University of Cincinnati.
	Columbus	F. C. Caldwell, Ohio State University.
	Toledo	W. E. Richards, Toledo Railway and Light Co.
OREGON:	Portland	F. H. Murphy, Portland Railway Light and Power Co. Electric Building.
PENNSYLVANIA:	Pittsburgh	L. O. Grondahl, Union Switch and Signal Co., Swissvale, Pa.
RHODE ISLAND:	Providence	F. A. Gallagher, Narragansett Elec. Lighting Co.
TEXAS:	Austin	J. M. Bryant, University of Texas.
UTAH:	Salt Lake City	R. H. Ashworth, Kearns Bldg.
VIRGINIA:	Charlottesville	W. S. Rodman, University of Virginia.
WASHINGTON:	Seattle	Fred. A. Osborn, University of Washington.
WISCONSIN:	Milwaukee	F. A. Vaughn, Metropolitan Block, Third and State Sts.
CANADA:	Montreal	L. V. Webber, 285 Beaver Hall Hill.
SOUTH AFRICA:	Johannesburg	H. A. Tinson, South African Gen. Elec. Co., Southern Life Buildings, Transvaal.

OFFICIAL REPRESENTATIVES TO OTHER ORGANIZATIONS

On the United States National Committee of the International Commission on Illumination	L. B. Marks Preston S. Millar
On American Institute of Electrical Engineers Standards Committee	Clayton H. Sharp
On Governing Board of the American Association for the Advancement of Science	Ernest F. Nichols Clayton H. Sharp
On the Advisory Committee, Engineering Division, National Research Council	Edward P. Hyde
On the Fixture Manufacturers Committee to prepare a Code of Luminaire Design	E. W. Commery J. W. Gosling S. G. Hibben M. Luckiesh R. H. Maurer A. L. Powell Samuel Snyder
On A. E. S. C. Sectional Committee, Building Exits Code	R. E. Simpson

COMMITTEES

1922-1923

Except as noted below, all committees are appointed by the President, subject to the approval of the Council, and terminate at the time of the first Council meeting of each new administration, in the month of October. The duties of each committee are indicated.

WARD HARRISON, President, Ex-officio member of all Committees.

(1) STANDING COMMITTEES AUTHORIZED BY THE CONSTITUTION AND BY-LAWS.

COUNCIL EXECUTIVE.—(*Consisting of the President, General Secretary, Treasurer and two members of the Council.) Act for the Council between sessions of the latter.*

Ward Harrison, Chairman.
Nela Park, Cleveland, Ohio.
Walton Forstall, Clarence L. Law,
S. G. Hibben, L. B. Marks.

FINANCE.—(*Of three members; to continue until successor is appointed.) Prepare a budget; approve expenditures; manage the finances; and keep the Council informed on the financial condition.*

Adolph Hertz, Chairman.
Irving Place & 15th St., New York, N. Y.
Walton Forstall, D. McFarlan Moore.

PAPERS.—(*Of at least five members.) Provide the program for the annual convention; pass on papers and communications for publication; and provide papers and speakers for joint sessions with other societies.*

J. L. Stair, Chairman.
235 W. Jackson Blvd., Chicago, Ill.
A. L. Powell, Vice-Chairman.
Fifth and Sussex Sts., Harrison, N. J.

E. A. Anderson, Howard Lyon,
Louis Bell, Norman D. Macdonald,
Geo. G. Cousins, F. H. Murphy,
H. H. Higbie, J. J. Ryan.
Albert Scheible.

Chairman of Section and Chapter Papers Committees, Ex-officio Members.

EDITING AND PUBLICATION.—(*Of three members.) Edit papers and discussions; and publish the Transactions.*

Norman D. Macdonald, Chairman.
80th St. and E. End Ave., New York, N.Y.
Allen M. Perry, Ralph C Rodgers.

GENERAL BOARD OF EXAMINERS.—(*Appointed by the President.) Pass upon the eligibility of applicants for membership or for changes in grade of membership.*

Norman Macbeth, Chairman.
227 W. 17th St., New York, N. Y.
Clarence L. Law, L. J. Lewinson.

(2) COMMITTEES THAT ARE CUSTOMARILY CONTINUED FROM YEAR TO YEAR.

LIGHTING LEGISLATION. — *Prepare a digest of laws on Illumination; coöperate with other bodies in promoting wise legislation on illumination; and prepare codes of lighting in certain special fields; to function also as a Technical Committee on Industrial Lighting.*

L. B. Marks, Chairman.
103 Park Avenue, New York, N. Y.
W. F. Little, Secretary.
80th St. and E. End Av., New York, N. Y.

Louis Bell, J. A. Hoeveler,
W. T. Blackwell, Clarence L. Law,
F. C. Caldwell, M. G. Lloyd,
C. E. Clewell, M. Luckiesh,
Geo. S. Crampton, R. H. Maurer,
H. B. Dates, A. S. McAllister,
E. Y. Davidson, Jr., W. J. Serrill,
W. A. D. Evans, R. E. Simpson,
S. G. Hibben, G. H. Stickney.

MEMBERSHIP. — *To obtain additional individual memberships.*

G. Bertram Regar, Chairman.
1000 Chestnut St. Philadelphia, Pa.,

J. F. Anderson, F. W. Bliss,
A. L. Arenberg, R. I. Brown,
C. A. Atherton, H. M. Camp,
W. T. Blackwell, W. E. Clement,

eorge G. Cousins, Merritt C. Huse,
errell Croft, L. B. Johnson,
. Daniels, C. C. Munroe,
. Y. Davidson, Jr., F. H. Murphy,
obert B. Ely, H. G. Smith,
. W. Everson, H. H. Smith,
. W. Fuller, E. W. Spitz,
. E. Hobson, Clare N. Stannard,
. A. Hoeveler, O. R. Toman,
L. A. S. Wood.

OTOR VEHICLE LIGHTING.

C. H. Sharp, Chairman.
oth St. and E. End Ave., New York, N.Y.

G. H. Stickney, Vice-Chairman.
Fifth and Sussex Sts., Harrison, N. J.

.C. Caldwell, W.F. Little,
. W. Devine, W. A. McKay,
. E. Godley, A. L. McMurtry,
. A. B. Halvorson, H. H. Magdsick,
.A.Hoeveler, L. C. Porter,
U. M. Smith.

. E. Voyer, Representative in State of Cal.

OMENCLATURE AND STANDARDS—*Define the terms and standards of Illumination; and endeavor to obtain uniformity in nomenclature.*

E. C. Crittenden, Chairman.
ureau of Standards, Washington, D. C.

Howard Lyon, Secretary.
Welsbach Co., Gloucester, N. J.

ouis Bell, C. O. Mailloux,
. A. Hoadley, A. S. McAllister,
. P. Hyde, E. C. McKinnie*,
. E. Kennelly, C. H. Sharp,
M. Luckiesh, W. J. Serrill,
G. H. Stickney.

ROGRESS.—*Submit to the annual convention a report on the progress of the year in the science and art of Illumination.*

F. E. Cady, Chairman.
Nela Park, Cleveland, O.

. S. Crampton, W. E. Saunders.

RESEARCH.—*Stimulate research in the field of illumination; and keep informed of the progress of research.*

E. P. Hyde, Chairman.
Nela Park, Cleveland, O.

Louis Bell, E. F. Nichols,
W. T. Bovie,* Thomas Scofield,*
Alex. Duane, C. H. Sharp,
Knight Dunlap, C. A. Skinner,*
E. N. Harvey,* L. T. Troland,
M. Luckiesh, F. H. Verhoeff.*

(3) TEMPORARY COMMITTEES FOR SPECIAL PURPOSES.

SKY BRIGHTNESS.

H. H. Kimball, Chairman.
U. S. Weather Bureau, Washington, D. C.

E. C. Crittenden, W. F. Little,
E. H. Hobbie, M. Luckiesh,
Bassett Jones, L. B. Marks.
I. G. Priest.*

COMMITTEE TO COÖPERATE WITH FIXTURE MANUFACTURERS

To Prepare Code of Luminaire Design

M. Luckiesh, Chairman,
Nela Park, Cleveland, O.
E. W. Commery, Secretary,
Nela Park, Cleveland, O

S. G. Hibben, R. H. Maurer,
J. W. Gosling,* A. L. Powell,
Samuel Snyder.

COMMITTEE ON NEW SECTIONS AND CHAPTERS

D. McFarlan Moore, Chairman,
Edison Lamp Works, Harrison, N. J.

COMMITTEE TO PREPARE A BULLETIN ON RESIDENCE LIGHTING BY GAS

Howard Lyon, R. H. Maurer.

COMMITTEE TO PREPARE A BULLETIN ON RESIDENCE LIGHTING BY ELECTRICITY

Samuel G. Hibben, Chairman.
165 Broadway, New York, N. Y

Geo. Ainsworth, M. Luckiesh,
F. E. Cady, W. R. M'Coy,
O. H. Caldwell, Herman Plaut,
W. J. Drisko, A. L. Powell,
R. B. Ely, F. B. Rae, Jr.,*
Gertrude R. Ferree,* R. C. Rodgers,
R. S. Hale, J. W. Smith,*
F. Y. Joannes,* J. L. Stair,
Clarence L. Law, E. D. Tillson,
D. H. Tuck

* Not members of the Society but coöperating in the work of these committees.

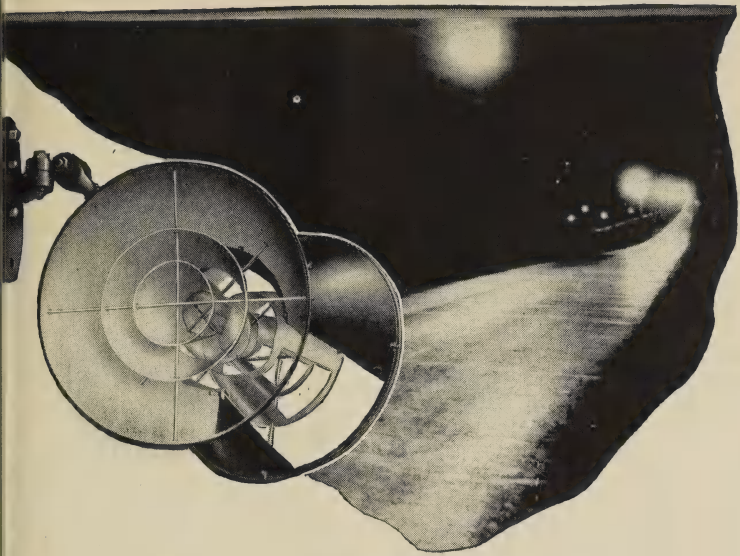
SUSTAINING MEMBERS

Alexalite Co., New York, N. Y.
American Gas & Electric Co., New York, N. Y.
American Optical Co., Southbridge, Mass.
Amherst Gas Co., Amherst, Mass.
Bangor Railway & Electric Co., Bangor, Me.
Bausch & Lomb Optical Co., Rochester, N. Y.
Beardslee Chandelier Mfg. Co., Chicago, Ill.
Benjamin Electric Manufacturing Co., Chicago, Ill.
Boss Electrical Supply Co., Providence, R. I.
Boston Consolidated Gas Co., Boston, Mass.
The Brascolite Co., St. Louis, Mo.
Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Brooklyn Union Gas Co., Brooklyn, N. Y.
Cambridge Electric Light Co., Cambridge, Mass.
Central Electric Company, Chicago, Illinois.
Central Hudson Gas & Electric Co., Newburgh, N. Y.
Commonwealth Edison Co., Chicago, Ill.
Consolidated Electric Lamp Co., Danvers, Mass.
Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Consolidated Gas Co. of New York, New York, N. Y.
Consumers Power Co., New York, N. Y.
Cooper-Hewitt Electric Co., Hoboken, N. J.
Corning Glass Works, Corning, N. Y.
Cox, Nostrand & Gunnison, Brooklyn, N. Y.
Cutler-Hammer Manufacturing Co., Milwaukee, Wis.
Dawes Brothers, Chicago, Ill.
Detroit Edison Co., Detroit, Mich.
Duquesne Light Co., Pittsburgh, Pa.
East Side Metal Spinning & Stamping Co., New York, N. Y.
Edison Electric Illuminating Co. of Boston, Boston, Mass.
Edison Lamp Works of General Electric Co., Harrison, N. J.
Electric Outlet Co., Inc., New York, N. Y.
Electrical Testing Laboratories, New York, N. Y.
Fall River Electric Light Co., Fall River, Mass.
Fitchburg Gas & Electric Light Co., Fitchburg, Mass.
Franklin Electric Light Co., Turners Falls, Mass.

SUSTAINING MEMBERS

)scar O. Friedlaender, Inc., New York, N. Y.
as and Electric Improvement Co., Boston, Mass.
eorgia Railway & Power Co., Atlanta, Ga.
illinder Brothers, Port Jervis, N. Y.
illinder & Sons, Inc., Philadelphia, Pa.
leason-Tiebout Glass Co., Brooklyn, N. Y.
loucester Electric Co., Gloucester, Mass.
reenfield Elec. Light & Power Co., Greenfield, Mass.
Iartford Electric Light Co., Hartford, Conn.
iaverhill Electric Co., Haverhill, Mass.
Iolophane Glass Co., Inc., New York, N. Y.
'he Horn & Brannen Mfg. Co., Inc., Philadelphia, Pa.
Iygrade Lamp Co., Salem, Mass.
Iydro-Electric Power Commission of Ontario, Toronto, Canada.
rving & Casson—A. H. Davenport Co., Boston, Mass.
Krich Light and Electric Co., Newark, New Jersey.
Kristiania Elektrecitetsvork, Kristiania, Norway,
E. B. Latham & Co., New York, N. Y.
Lawrence Gas Co., Lawrence, Mass.
Leeds & Northrup Co., Philadelphia, Pa.
Lightolier Co., New York, N. Y.
Lundin Electric & Machine Co., Boston, Mass.
Lynn Gas & Electric Co., Lynn, Mass.
Macbeth-Evans Glass Co., Pittsburgh, Pa.
Malden Electric Co., Malden, Mass.
Malden & Melrose Gas Light Co., Malden, Mass.
McGraw-Hill Publishing Co., New York, N. Y.
Millville Electric Light Co., Millville, N. J.
Montpelier & Barre Light & Power Co., Montpelier, Vt.
Narragansett Electric Lighting Co., Providence, Rhode Island.
National Lamp Works of General Electric Co., Nela Park, Cleveland, Ohio.
National X-Ray Reflector Co., Chicago, Ill.
New Bedford Gas & Edison Light Co., New Bedford, Mass.
Newburyport Gas & Electric Co., Newburyport, Mass.
New England Power Co., Worcester, Mass.
New Haven Gas Light Co., New Haven, Conn.
New York Edison Co., New York, N. Y.
New York & Queens Electric Light & Power Co., Long Island City, N. Y.

Pennsylvania Power & Light Co., Allentown, Pa.
Peoples Gas Light & Coke Co., Chicago, Ill.
Pettingell-Andrews Co., Boston, Mass.
Philadelphia Electric Co., Philadelphia, Pa.
Philadelphia Electric Manufacturing Co., Philadelphia, Pa.
Pittsfield Electric Co., Pittsfield, Mass.
L. Plaut & Co., New York, N. Y.
Portland Railway, Light & Power Co., Portland, Ore.
Potomac Electric Power Co., Washington, D. C.
Providence Gas Co., Providence, R. I.
Public Service Corporation of New Jersey, Newark, N. J.
Public Service Company of Northern Illinois, Chicago, Ill.
Rochester Gas & Electric Corp., Rochester, N. Y.
Max Schaffer Company, New York, N. Y.
Salem Electric Lighting Co, Salem, Mass.
Shapiro & Aronson, Inc., New York, N. Y.
Slocum & Kilburn, New Bedford, Mass.
Societa Idroelettrica Piemonte, Turin, Italy.
Southern Electric Co., Baltimore, Md.
Sterling Bronze Co., New York, N. Y.
Stone & Webster, Boston, Mass.
Suburban Gas & Electric Co., Revere, Mass.
The United Gas Improvement Co., Philadelphia, Pa.
Charles H. Tenney & Co., Boston, Mass.
Tungsten Wire Works, A. B., Stockholm, Sweden.
Union Gas & Electric Co., Cincinnati, Ohio.
Union Light & Power Co., Franklin, Mass.
Union Electric Supply Co., Providence, R. I.
United Electric Light & Power Co., New York, N. Y.
United Electric Light Co., Springfield, Mass.
Alfred Vester Sons, Providence, R. I.
Welsbach Co., Gloucester, N. J.
Welsbach Street Lighting Co., Philadelphia, Pa.
Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
Westinghouse Lamp Co., Bloomfield, N. J.
Wetmore-Savage Co., Boston, Mass.
Worcester Electric Light Co., Worcester, Mass.
Worcester Suburban Electric Co., Palmer, Mass.



A Source of Income for Central Stations

Increasing enthusiasm for good roads has brought with it an interest in their proper illumination that can be turned to good account by live central stations. As a load builder, highway lighting involves sufficient steady revenue to be well worth the consideration of any light and power company.

The General Electric Company's system of highway lighting, with fixtures that spread the light on the road, offers a splendid opportunity for local campaigns in behalf of this form of lighting.

One 250 c.p. lamp every 300-500 feet (thirty feet above the road-side) will provide adequate illumination without glare (approximately 1750 c.p. at an angle of 10 degrees below horizontal). This minimizes accidents, adds to the comfort of night driving and discourages lawlessness.

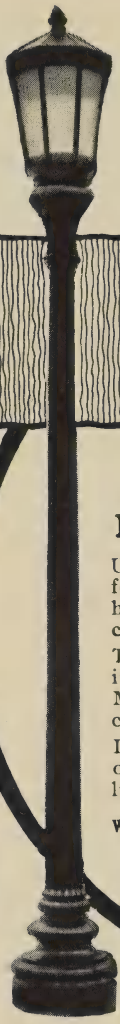
The street lighting specialist in our nearest district office will gladly give further information and assist in a local campaign for road lighting.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

35C-115



TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

OFFICE OF PUBLICATION: EASTON, PA.

Published monthly except June and August under the direction of the Committee on Editing and Publication.

DATES OF PUBLICATION:

No. 1, January	No. 2, February	No. 3, March
No. 4, April	No. 5, May	No. 6, July
No. 7, September	No. 8, October	No. 9, November
	No. 10, December	

SUBSCRIPTION, $7.50 PER ANNUM SINGLE COPIES, $1.00
FOREIGN SUBSCRIPTION, $8.00 PER ANNUM

ADVERTISING RATES MAY BE HAD UPON APPLICATION
TO THE GENERAL OFFICES OF THE SOCIETY,
29 WEST 39TH STREET, NEW YORK, N.Y.

ENTERED AS SECOND-CLASS MATTER AT THE EASTON, PA. POST OFFICE
ACCEPTANCE FOR MAILING AT SPECIAL RATE OF POSTAGE PROVIDED FOR
IN SECTION 1103, ACT OF OCTOBER 3, 1917, AUTHORIZED JULY 16, 1918

TRANSACTIONS

OF THE

Illuminating Engineering Society

SCOPE—An authoritative technical publication of the Illuminating Engineering Society covering, in well written articles, every phase of development in the arts and sciences related to *illuminating engineering*; describing the design, manufacture, and installation of lighting equipments; pointing out the technical, artistic, utilitarian, aesthetic, psychological and physiological aspects; and presenting data and facts derived through the work of specially chosen committees and individuals.

AUTHORS—Illuminating engineers, architects, educators, scientists, manufacturers of lighting equipments, glassware, lamps and accessories, research engineers, artists, physicians, ophthalmologists, state and municipal authorities.

EDITING—Performed under the direction of committees of technical experts, who select the authors, approve the papers and discussions and direct the policies of publication.

PUBLICATION—In ten issues per year; publishing annually from 600 to 1,200 pages of live material of permanent reference value. Printed on a no-glare suede finish paper—resulting in a pleasing appearance of the printed page and reading clearness without eye-strain.

CIRCULATION—To all members of the Society (now 1,450); University, College and Public Libraries in the United States and foreign countries; technical libraries of industrial and commercial organizations.

CURRENT SUBSCRIPTIONS—To individuals $7.50 per year, payable in advance. Single copies $1.00 each. All foreign subscriptions $8.00 per year. A discount of 10% is allowed to Libraries and Agents.

BACK VOLUMES—The TRANSACTIONS have been published since 1906—seventeen volumes Due to the demand for back numbers and the scarcity of early issues, orders for back volumes or back issues are accepted subject to delay in fulfilment. Quotations given on request.

Inquiries for further information and samples of current copies, returnable after inspection, should be addressed to

ILLUMINATING ENGINEERING SOCIETY

29 West 39th Street New York, N. Y.

TRANSACTIONS

OF THE
ILLUMINATING ENGINEERING SOCIETY

"......the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto"

Featuring

New Developments in Art Gallery Illumination

By Kirby and Champeau

VOL. XVIII. JULY, 1923 NO. 6

SEVENTEENTH ANNUAL CONVENTION, I. E. S.

LAKE GEORGE, N. Y., SEPT. 24-28, 1923

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

Vol. XVIII JULY, 1923

TABLE OF CONTENTS

In Memoriam, Louis Bell — A. E. Kennelly

Big Lights for Night Flights
Electric Lamps Will Aid Sun in Growing of Laboratory Plants
Non-Fading Light Needed to Preserve Colors
200,000,000 Tungsten Lamps Sold in 1922

New Developments in Art Gallery Illumination — G. T. Kirby and L. X. Champeau
Discussion Grand Central Art Gallery Lighting
Aesthetic and Utilitarian Values of Luminaires — E. G. Perrot

Abstracts

Society Affairs

Illumination Index

PUBLISHED MONTHLY EXCEPT JUNE AND AUGUST BY THE
ILLUMINATING ENGINEERING SOCIETY
PUBLICATION OFFICE, 125 W. STATE ST., ITHACA, N. Y.
EDITORIAL OFFICE, 29 W. 39 ST., NEW YORK CITY

ENTERED AS MATTER OF SECOND CLASS AT THE ITHACA, N. Y. POST OFFICE
ACCEPTANCE FOR MAILING AT SPECIAL RATE OF POSTAGE PROVIDED FOR IN SECTION 1103, ACT OF OCTOBER 3, 1917, AUTHORIZED JULY 16, 1918

IN MEMORIAM

Louis Bell

1864-1923

THIRD PRESIDENT

ILLUMINATING ENGINEERING SOCIETY

Resolution Adopted by the Council of the Illuminating Engineering Society
June 28th, 1923.

The Officers and Council of the Illuminating Engineering Society hereby record their sense of loss in the passing of their friend and co-laborer, Dr Louis Bell. His death removes an active, enthusiastic and effective contributor to the science and art of illumination; a pioneer in this as in other fields of scientific endeavor; a leader in establishing illuminating engineering as a distinct specialty; an authority of recognized distinction in this field; and the third President of this Society.

The many friends of Dr. Bell will long cherish the memory of the cultured gentleman whose rare blend of comprehensive knowledge, never failing humor and loyal comradeship endeared him to all who were privileged to know him.

For the Council

Ward Harrison
President

Samuel G. Hibben
General Secretary

LOUIS BELL
1864-1923

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVIII | JULY, 1923 | NO. 6

In Memoriam

LOUIS BELL

BY A. E. KENNELLY

THE late Dr. Louis Bell was so well known to members of the Illuminating Engineering Society, as a Past-President, leader and author, that a brief account of his personality, career and accomplishments is sure to be welcome to many.

Louis Bell was the grandson of Governor Samuel Bell of New Hampshire, who represented that state for two terms in the U. S. Senate at Washington, D. C. His father was General Louis Bell, who fought in Grant's army during the Civil War. General Bell, when 28 year old, commanded the attack on Fort Fisher, and was killed in action during the last few minutes of the final successful rush on the trenches, just before the close of the war. The news of his death came as a terrible shock to his young wife, in the family home at Chester, N. H., and she survived him only six months, leaving little Louis, then one year old, (born Dec. 5th, 1864), and his sister four years older. The two children were brought up at Chester, by their grandmother, Governor Samuel Bell's widow. In remote village life, these two children were thrown much on their own resources, and mingled but little with the outer world. Louis was gifted mentally, and was given his bent in study, with full encouragement by his fond grandparent. The boy was an omnivorous reader, even at the age of eight, and was consumed

with a thirst for knowledge of all kinds, but particularly for scientific knowledge. I used to wonder, in later years, how Dr. Bell became so well versed in the bible and bible history, until I learned that he was frequently allowed to choose, on Sunday mornings, between going down the hill to church, and staying home to learn a chapter of scripture by heart. Little Louis, with his swift memory, always chose the latter alternative.

When Louis was twelve years old, it was decided that he should be taken from his native village and sent to school at the Phillips Exeter Academy, Exeter, N. H. Thereafter, he only returned to Chester for brief and occasional visits; but he was very deeply attached to his childhood's home and he always desired to be carried back there after his death. He was rather a lonely lad at school, brilliant but living apart. His letters to his sister show how close was their attachment, and how much he depended on her guidance. When she died untimely at twenty-one, he was distracted with grief. He would never trust himself to speak of her in after life, even to his most intimate friends.

Louis entered Dartmouth, the college of his family, in 1880, and took his A. B. degree there is 1884. In his studies, he distinguished himself in chemistry and physics, and took post-graduate college work in physics. The Professor of Astronomy there allowed Louis to live at the College observatory, and to use the telescopes for observations, during two summers. Bell always loved a telescope and admired those who knew how to use them.

Bell was always a most loyal and devoted alumnus of Dartmouth, giving, throughout his life, unstintedly of his time and efforts to her aims. From Dartmouth, he went to Johns Hopkins University, where he studied under Rowland, and where he took his Ph.D. degree in 1888.

The subject of his thesis was "The Absolute Wave Length of Light." At the Manchester British Association Meeting in September 1888, Dr. Bell presented a joint paper by Prof. Henry A. Rowland and himself on "Explanation of the Action of a Magnet on Chemical Action."

After graduating at Johns Hopkins, Dr. Bell went to join, for a year, the faculty of Purdue University, as Professor of applied electricity, or what is now generally known as electrical engineering. This was a new chair at that time in Purdue. He organized the electrical engineering instruction there on a sound basis, and in 1890, he went to New York, as editor of the "Electrical World," which has since continued to be a prominent electrical engineering weekly journal. At that time, it was owned by W. J. Johnston. It was during this period that I first became acquainted with Dr. Bell as the editor of the "Electrical World." Ever after that interview, I was his admirer and friend. Bell was always a very clear and forceful writer. It was fortunate for the "Electrical World" that its editor, in Dr. Bell, was not only a prominent electrical engineer, but also a good scholar in English. He left the chief editorship in 1892, to enter the service of the General Electric Co., but he maintained literary connection with the "Electrical World", editorially and otherwise, up to his death. Anyone acquainted with the personal characteristics of his literary style, could readily discern articles by him. He had the gift of writing in such a manner as to compel attention and understanding. There was frequently a background of quaint humor in his articles, that tempted the reader to follow, even when the subject was dry and difficult.

It was about 1892, that the alternating-current motor began to enter commercial development. Dr. Bell, as chief engineer of the then newly organized power-transmission department of the General Electric Co., designed and installed some of the first polyphase power-transmission plants in the country. It was at Redlands in California, that one of these early induction-motor plants was installed, and Bell attended to it in person. One of his induction motors was direct connected to an air compressor of considerable power. Up to that time, alternating-current motors had not been notorious for powerful starting torque under load, and the superintendent of the Redlands compressor looked with

some disdain on the new induction motor, which he considered much two small for the work. Bell, who had made thorough factory tests of the motor, knew what it could do when started under load, and impressed upon the superintendent the great importance of not closing the motor switch at the receiving end of the polyphase line, unless the outlets of the compressor were open. In his disdain of the new induction motor, however, the compressor man forgot these injunctions, and one day he closed the starting switch of the motor with the compressor outlets tightly shut. Bell was at the other end of the line at the time, near the generators, and saw the load come on at his switchboard. He could follow what happened at the motor by watching the instruments. The motor got under way for a short interval, evidently heavily loaded. Then there was a groan at the generator, and the automatic circuit-breakers opened at the motor end of the line. At the compressor plant, the motor had carried the compressor to such a point that, with no relief available, the crank shaft had broken, and the coupling bent. It took some time to repair the damages, but after that, the compressor men always treated that induction motor with great respect, and described it as "heap big medicine."

In 1892, Dr. Bell published (with Oscar T. Crosby) "The Electric Railway," which was a pioneer book on the subject. In 1896, he himself wrote "Power Transmission for Electric Railroads," and in 1897, "Electric Power Transmission," both of which books were soon widely known.

In 1895, he entered the profession of consulting engineering in Boston. He continued in this work for the rest of his lfe. At first, his work dealt mainly with electric power transmission, but afterwards he took up electric lighting more particularly, and later on he specialized in electric illuminating engineering. He published, in 1902, the text book "The Art of Illumination," which became a classic in that field. He lectured frequently on illumination both at Harvard University, the Massachusetts In-

stitute of Technology and elsewhere. He was President of the Illuminating Engineering Society in 1908, and was an active member of several of its important committees. He continued to work for the Society up to the last. He was also, for about ten years, a Vice-President of the Illuminating Engineering Society of Great Britain.

Although he was always engaged in engineering work, he was keenly interested in pure science, especially in optics and optical astronomy. His book "The Telescope," published in 1922, is delightful to read, both from the practical and historical, as well as the purely optical view points. He was a member of the American Astronomical Society, and of the Board of Visitors of the Harvard Observatory.

He was a member of the American Academy of Arts and Sciences, was on its Rumford Medal Committee, and contributed various papers to its volumes, particularly on optics. A list is appended of his papers in the Proceedings of the Academy, and in those of the Illuminating Engineering Society, only. No attempt will be made here to give a list of his contributions to technical literature generally, because their name is legion. The fertility of his inventiveness is also shown by the fact that he took out more than forty patents, mainly in the applications of optics and illumination.

During the Spanish American War, Dr. Bell was Technical Officer of the Volunteer Electrical Corps, dealing with electrical harbor and Atlantic coast defenses from the Chesapeake Bay to the Canadian Border.

In the Great War, he was a member of the Advisory Committee on the Council of National Defense. He was specially occupied with telescopic sights for naval guns. He also developed a very practicable system of invisible signalling by ultra-violet light.

Dr. Bell married Sarah G. Hemenway of Somerville, Mass. in 1893, who with his son Louis and two grandchildren, survives

him. Bell was a home-making and home-loving man, shining most brightly when acting as host. He was a witty and gracious conversationalist, loving, for its own sake, a humor which never degenerated into satire or sarcasm.

In his leisure hours, which were rather few and far between, Bell enjoyed rifle and revolver shooting. He was always a good marksman, and indeed maintained, in that way, a family tradition of several generations. The Bells were always good shots. He was a member, and had been the President, of the Massachusetts Rifle Association. He also held at one time (New York, 1892) the American amateur revolver-shooting championship. In 1903, he was one of a team of the American Revolver Association which won an international shooting match with a similar French team. He would often spend his Saturday afternoons on the rifle range at Walnut Hill, Mass., where he was very popular and had many friends. He looked upon the rifle rather as an instrument of scientific precision in target hitting, than as a deadly weapon. He was, on the other hand, however, an eager student of military history.

Some two years ago, his usually robust health broke down with an attack of pneumonia and after that it failed rapidly; but his courage was invincible. At the last, he had great hopes, although in reality quite illusory hopes, of recovery. He passed away, happily, during sleep, on June 14, 1923. His final resting place is among the tombs of his kindred, at the quiet village cemetery of Chester, in the farming country of New Hampshire, where many of the old present homesteads were celebrated in colonial times.

Five days after his death, the posthumous honorary degree of Doctor of Science was awarded to him by his alma mater, Dartmouth College. Dr. E. M. Hopkins, the President, delivered on that occasion the following allocution, which Dr. Bell's numerous friends will heartily endorse:

"Louis Bell, teacher, writer, investigator; pioneer in the development of electrical transmission; authority in the fields of illumination and optics; fruitful in the work of making the accumulations of the laboratory of service to mankind; whose scientific achievements have been combined with wide interest in literature and art, and who, as a writer and lecturer, has brought literary finish and quiet humor to the exposition of sound common sense; loyal alumnus of the college, and ever interested in her welfare".

PUBLICATIONS BY DR. LOUIS BELL IN THE PROCEEDINGS OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES

"The Physiological Basis of illumination." Vol. 43, No. 4, 1907.

"Note on some Meteorological Uses of the Polariscope." Vol. 43, No. 15, 1907.

"On the Opacity of Certain Glasses for the Ultra-violet." Vol. 46, No. 24, 1910.

"On the Ultra-violet Component of Artificial Light." Vol. 48, No. 1, 1912.

"Types of Abnormal Color Vision." Vol. 50, No. 1, 1914.

"The Pathological Effects of Radiant Energy upon the Eye." (with F. H. Verhoeff and C. B. Walker), Vol. 51, No. 13, 1915.

"Ghosts and Oculars." Vol. 56, No. 2, 1920.

"Notes on the Early Evolution of the Reflector." Vol. 57, No. 4, 1921.

PUBLICATIONS BY DR. LOUIS BELL IN THE TRANSACTIONS OF THE ILLUMINATING ENGINEERING SOCIETY

"The Illumination of the Building of the Edison Electric Illuminating Company of Boston" (with L. B. Marks and W. D'A. Ryan). Vol. II, No. 7, 1907.

"Coefficients of Diffuse Reflections." Vol. II, No. 7, 1907.

"Response to the Address of Welcome to Convention." Vol. IV, No. 7, 1909.

"The Principles of Shades and Reflectors." Vol. IV, No. 8, 1909.

"Street Photometry." Vol. V, No. 5, 1910.

"Photometry at Low Intensities." Vol. VI, No. 7, 1911.

"Report of Committee on Progress" as Chairman of Committee. Vol. VI, No. 7, 1911.

"The Pathological Effects of Radiation on the Eye" (with F. H. Verhoeff). Vol. XVI, No. 9, 1921.

"Report of Sub-Committee on Glare" as Chairman. Vol. XVII, No. 10, 1922.

REFLECTIONS

Big Lights for Night Flights

GREAT electric beacons capable of generating a beam of a half billion candlepower will guide pilots of transcontinental mail planes in their night flights.

One of these huge lights, to be the western terminal of a chain of beacons, is on its way today to Cheyenne, Wyo,. from the Brooklyn plant of the Sperry Gyroscope Company.

The non-stop flights are to be so timed that east of Chicago and west of Cheyenne the flying in either direction will be by daylight. Between those two cities will be what aviators call a "dark belt."

As the pilot passes over Chicago at sunset he will peer ahead, and some hundred miles distant will see the 500,000,000 candlepower beacon whirling around at a low angle at three revolutions a minute. He will direct his flight to the source of this light.

When he has passed it he will glance backward, guiding himself by the light he has left behind until he picks up the rays of the next series of beacons. Five of these lights will be spaced at 200-mile intervals, covering the dark zone, approximately 1,000 miles. They will be at Chicago, Iowa City, Iowa; Omaha, North Platte, Neb., and at Cheyenne.

Two lights are already in place. The apparatus shipped yesterday is the third, and two more will be dispatched soon. Less powerful beams set at stations about twenty-five miles apart along the air lane will illuminate fields where emergency landings may be made. *The Evening Mail,* June 13, 1923.

Electric Lamps Will Aid Sun in Growing of Laboratory Plants

A STATEMENT issued yesterday by Dr. William Crocker, research director of the new Thompson Institute for Plant Research which Col. William B. Thompson is establishing in Yonkers at a first cost of more than $500,000, gave further details of the plan by which powerful electric lamps are to supplement sunlight in growing plants. Eventually the institution is to cost $2,500,000.

"This new institution, with its gardens, greenhouses and laboratories," said Dr. Crocker, "is to be to plants and flowers what the Rockefeller Institute is to humanity. In other words it is to study and try to cure diseases of plants and flowers and other vegetation."

Dr. Crocker has had wide experience as head of plant physiology of the University of Chicago. On the board of trustees are the business group, consisting of Col. Thompson, C. C. Dula and Theodore Shulz, and the scientific group, including Prof. John Coulter of the University of Chicago, Prof. L. R. Jones of the University of Wisconsin, Dr. Raymond Foss Bacon, consulting chemist of New York City, and Dr. Crocker.

Col. Thompson said recently: "In another century this country must feed, clothe and shelter several hundred millions of people instead of 100,000,000 as now."

The laboratories are to be located on a nine acre plot at 1086 North Broadway, Yonkers.

In these chambers the temperature, humidity, carbon dioxide concentration of the air and the quality, intensity and duration of light can be adjusted at will and automatically maintained. In other words, the experimenter can manufacture climate and atmosphere to suit the needs of the experiment. *New York Herald*, June 24, 1923.

Non-Fading Light Needed to Preserve Colors

THERE are numberless examples of paintings which have faded beyond all semblance of their pristine selves. Very serious loss of color has taken place in many museum specimens which it was imperative to preserve as nearly as possible in their original state. In an endeavor to combat this deterioration Sir Sydney Harmer of the British Museum has within the last few years conducted a long series of experiments to determine the character of color changes produced by the exposure of pigments to sunlight or other light, the cause of these color changes in so far as it may be ascertainable, and particularly the possible remedies. The experiments were made by exposing pigmented and other objects under plain and tinted glasses with a control series under black glass, the exposure lasting for several years. The screening glasses covered a range from practically light window glass to a strongly absorbing glass similar to what used to be known as

Euphos ordinary yellow green, cutting off all the ultra-violet and most of the violet and blue. This last-named glass had decidedly too strong a color to be a satisfactory permanent housing. Years before this same ground had been, for the same good purpose, pretty thoroughly explored by Dr. Russell and Sir William Abney.

The first fact which was clearly established was that, on the whole, fading from the action of light does not ordinarily take place in the absence of oxygen and moisture. This immunity probably does not extend to some of the very fugitive dyes like erythrosine, but the relation is generally true that where there is no oxygen and no water there is no fading. Moreover, as might be anticipated from our general knowledge of photochemical reactions, the strongest fading effects were produced by direct sunlight, which was at least a score of times more injurious than the strong devised daylight. The control experiments, which freely let through a large part of the heat associated with the illumination, showed plainly that the effect of heat as such was substantially negligible.

Fading due to artificial electric light was much less than even with devised daylight—about one-sixth as much according to the experiments—the electric light used for the comparison being a powerful gas-filled incandescent lamp. Such a lamp is by no means free from ultra-violet radiation; hence there is the probability that a toning screen which would hold down the radiation on objects to something substantially within the limits of the visible spectrum would be of material assistance in still further preventing fading. Indeed, artificial daylight, when not abnormally rich in blue, gives promise of displaying colored objects as in a museum to better advantage in many respects than natural daylight. However, one must remember that while a great deal of photochemical activity has been charged up to the ultra-violet light, pretty nearly every part of the spectrum has under favorable circumstances a chemical effect upon something.

From a practical standpoint it would seem to be worth while to work out a source of non-fading light and then take up wherever possible the additional problem of preserving valuable objects with a still greater probability of success by sealing them from the air. There is probably no such thing as absolute prevention of all fading, but if the danger could be put far off down the centuries by means which now can be easily applied the end would seem well worth the effort. *Electrical World*, May 12, 1923.

200,000,000 Tungsten Lamps Sold in 1922

THE total sales of tungsten filament incandescent lamps (excluding miniature lamps) in the United States during 1922 amounted to slightly over 200 million lamps. This is a 25 per cent increase over the 1921 sales of 160 millions, and is within one per cent of the 202 millions sold in 1920.

There were less than three million carbon lamps sold in 1922, compared with six million in 1921 and nine million in 1920. It is apparent that the carbon lamp will soon disappear from the market; it is now a negligible item in the total lamp sales.

Lamp manufacturers have developed a coloring material for lamps which has been very satisfactory. It is sprayed on the lamp, is weatherproof and does not fade. It is much better than the artificial coloring material previously used, which was applied by dipping the lamp in the coloring solution. It faded rapidly and was not weatherproof.

The sprayed color is even more uniform in color than natural colored glass bulbs which vary in color due to variation in density and thickness of individual bulbs. Sprayed colored lamps can be supplied more quickly than natural colored glass lamps, as the sprayed color can be quickly applied to clear lamps in stock, whereas the natural colored glass lamps usually have to be made to order and often the bulbs have to be specially blown. Only four colors are supplied, which are a standard shade of red, blue, green and yellow.

The sprayed colored lamp is no more expensive than dipped colored lamps and is cheaper than natural colored glass. The sprayed color can also be satisfactorily used on Madza C lamps up to and including the 150-watt size.

Colored lamps are less efficient than clear or frosted lamps and should therefore be used only for decorative purposes. *N. E. L. A. Lamp Committee Report.*

PAPERS

NEW DEVELOPMENTS IN ART GALLERY ILLUMINATION*

BY G. T. KIRBY AND L. X. CHAMPEAU**

SYNOPSIS: In this paper the authors point out the importance of the proper lighting of art galleries, that is, to light each object as nearly as possible in the same manner as when the object was executed, without interfering with the architecture of the room or devoting special space for individual objects.

They explain how with deflectors and prismatic glass they control the daylight bringing it to the objects at the proper angle, and maintaining it at that angle and intensity throughout the day and the seasonal changes.

The authors further explain how with special lenses and deflectors they succeeded in producing artificial light of nearly a uniform intensity the full height of the picture zone, that compared favorably with the daylight. This was accomplished without sacrificing the architecture of the room and without glare.

If we have made a success of the lighting of The American Art Galleries, as we believe we have, it is due to the fact that we know what Art Galleries are; what the needs of the lighting of Art Galleries are and with careful study and many experiments, we have brought about a good sound result. Of course, you often start with a theory and I am mighty proud of the fact that years ago—many more years than most of you here can boast of—I was an undergraduate in the school of Mines and had the rare good fortune of studying under two great men among other great men. One was Prof. Hallock (then Professor of Physics) who is now dead. The other was Professor Pupin, then Professor of Electrical Engineering, as he is today, one of our greatest, if not our greatest, scientist.

*A paper presented before the New York Section of the Illuminating Engineering Society, April 3, 1923.

**Kirby, Champeau Co., Inc. ,New York City.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

Hallock was always "bugs" on lighting. It was his fad and fancy in every way. Some of you may remember that not long after the beautiful library up on Morningside Heights was built, the lighting there was very poor. So Hallock placed right in the center of that dome a tremendous globe and he threw on to that globe from four or eight corners of the rotunda, lights which were reflected down upon the writing desks and gave a general soft illumination to the entire library.

Well, I thought that was a great stunt. So it happened that a few years afterward when I got some lighting ideas in my own head, I went up to Hallock and he and I had a heart-to-heart talk as to whether I was an awful fool or somewhat of a wise man and whether I should go ahead on it.

Shortly after, Hallock died and Cushman helped me out in a lot of these experiments. I had the craziest ideas that a young man ever had. I thought we could put up in this town a forty-story building. However, big art galleries need to be near the sidewalks because ofttimes when we have an exhibition such as we have on now, there are literally thousands of persons coming in every day to see them, and you can't carry a crowd as big as that in elevators; so you must have, as you see we have, wide stairways leading up to the rooms in order to give ready access to and from them.

Real estate is so expensive in New York that I thought we would combine the art galleries on the second floor and occupy the space above. So my bughouse plan was to put a forty-story building on the plot but have about ten stories over the second story vacant, the idea being that the daylight would come in from all four sides and come down through the skylights and light up the rooms and objects therein. It would have been all right if the building had been out on a plain, but I promptly, in my theory, forgot that adjoining buildings would soon go up around us and that those side lights would be shut off.

It is very important in showing artistic property to be able to show it in its true color value. The artist goes out into the field or into a studio to paint; he does not do it by artificial light. His color values, his color balance is as the daylight shows them. Of course, his picture, or tapestry or fabric, whatever it may be that he is working on, may be equally beautiful under a yellow gas

light or an old-fashioned carbon filament or whatever the illuminant may be, but, even though it is beautiful, it is seldom if ever under such artificial light shown in the same way as the artist painted it and as the artist intended it to be seen.

Another thing which one should always remember is that the light coming from directly over a picture or even a tapestry or any art object, ofttimes throws shadows from the pigment or from the material in a way that the artist never intended, distorting his drawing and giving it a very different effect from what the picture was intended to give. All you have to do to prove that very important point is to notice the thousands of advertising signs as we now see them when we walk up and down our streets and avenues—first we see a young lady putting on a stocking; then we go about five feet more and she is taking it off, or something like that. You know what they are better than I. But that is the whole thing; it is the angle from which you look at it, the angle from which the light strikes those lines.

So, in illuminating a beautiful artistic object, you have to be very careful that the rays of light, whether they are daylight or artificial, strike the object in the way that the artist intended they should strike it and in the way that the artist painted.

When you walk through these galleries—as you are going to do very shortly—and have the pleasure not only of seeing our lighting devices, but of seeing the greatest collection of highly artistic property which for many and many a year has been gathered together (The Solomon Collection) just note how clearly not alone the color values come out, but how clearly you see the picture, as if daylight instead of electric light were the illuminant.

You, of course, are only secondarily interested in daylighting, but you should be very much interested in it because one great thing in art galleries is to have the lighting so that when you change from your daylight to your artificial light or from your artificial to daylight, it will hardly be observed. Many times in these Galleries, when the crowds come up in the daytime and it suddenly becomes dark—as it has several times this spring— we switch on the artificial light and the people in the Galleries at the time do not know whether there has been any change or not. That is a very good test of your lighting efficiency.

Of course, in daylight, (if I may speak of that for a moment) as we all know, the artist is striving for what is called "North

light." It really does not make much difference where the light comes from, whether it is north, south, east or west. What he is really striving for is a reflected light, a light that comes from a million and one different points. As old Hallock used to say, "What he is striving for is the million reflectors, little dust motes in the atmosphere that reflect the sun," because, after all, the sun is the source of our daylight and it would be very easy to give an absolutely correct daylight at all times were it not that, as the old colored preacher proclaimed, "the sun do move."

It was only the day before yesterday that I went into one of our best known galleries here in the city, and let us say there (indicating) was the north wall, this (indicating) the south, behind me is east, of course, and that (indicating) is west. It was about one o'clock and the sun at this time of the year is somewhat in the south, as you know. That north wall which was covered with prints was simply bathed in a glorious yellow sunlight, and that wall (indicating) was in shadow. Well now, it was beautiful as an object of sunlight, but to show anything on the walls was simply absurd because that wall (indicating) should have been of the same illumination as that (indicating) and the east and the west.

What we have done here, as Mr. Champeau will show you much more plainly than I can because he is the practical man, is really to construct louvers which, in effect at all hours of the day, redirect the varying sunlight and give it a constant direction. It would be easy if the light were always coming down from above; then you could diffuse it without any difficulty. As it is, it comes up here low in the east and we have horizontal deflectors which let the same amount of light through as it reflects to the opposite wall; and we have vertical deflectors which do the same for the east and the west walls which the horizontals do for the north and south.

It might very well be described as a lot of cubes. You have seen eggs packed in such pasteboard boxes; that is exactly what we have over our skylights, the sides are parallel when the sun is east and west, but as the sun passes from east to west the vertically pivoted deflectors are kept at right angles to a vertical plane passing through the sun and the sides of the cubes are then "lop sided." The material of the sides of those little compartments instead of being opaque are of diffusing substance, so that

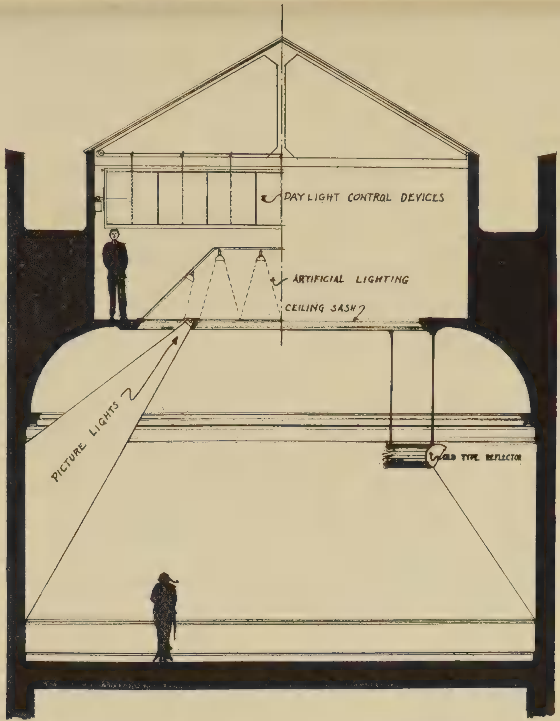


Fig. 1—Diagram of a typical installation of devices for day and night lighting of galleries.

Fig. 2—Stair hall and corridor. The main source of light at night is behind the ceiling sash while the ornamental chandeliers with their shaded bulbs give a pleasing touch of light, and appear to be the only source of light.

Fig. 3—Showing end and side of typical gallery by daylight; note the uniform lighting of walls and lack of intense light usually found in center of galleries.

Fig. 4—Same gallery as above viewed at night.

some of the light goes through to the wall facing the sun and an equal amount is reflected to light the wall facing away from the sun.

In other words, the light is scattered, and that is what you want to do. You want to break it up so that no direct sunlight will reach the gallery.

This apparatus serves the purpose very well but the downward component of light is still too great, lighting the center of your room more than the walls, and you would have with that lighting, an effect very much the same as you have in this room. You are sitting here in a light that you can read by, that you can see each other by, but your walls are comparatively dark. In the main Gallery which Mr. Champeau and Mr. Day will show you, that light as it comes down is taken by prismatic glass and thrown to the four walls. So that, instead of coming directly down, it comes down to that glass and then it is bent and sent to the walls. Therefore, in that room you will find a practically even illumination, not alone of the walls, but of the floor and it is done without hanging that hideous and unnecessary canopy from the top or by putting in any of the many devices which are eye-sores and which you see in so many museums.

Now we come to the night lighting which is equally if not more important, because it has to do not alone with galleries where you must have your top lights for the color values of which I have spoken, but also for homes, for places where pictures and tapestries and other beautiful things are shown. What we have done in the Galleries is just as adaptable for homes as it is for the Galleries. In point of fact, we have just installed in the home of one of our young men of good fortune and good philanthropy as well, reflectors to light his million dollar tapestries.

The great trouble with most of our reflectors which help in the illumination of our walls in galleries and other places is that we have to drop them down from the ceiling. When we do that, we are doing something which is bad in many ways. Primarily, it looks bad. You don't like to see something hanging down in that way. Next: It cuts right around the wall so that if you were looking at a large picture or a tapestry or hanging, you have that line of your reflector everlastingly in your eyes. Next, and just as important: In the daytime, when the light comes from your skylight, you have the shadow of that reflector thrown on the wall

thereby putting the shadow on the picture or whatever is there, and you can't cut it out. Even here where there are no shades to draw, where these louvers or deflectors take the place entirely of shades, and where we can cut out all the light or a large part of it any time we want to, there is always that shadow where there is a hung reflector. So you will find that our reflectors are right up in the ceiling where the skylights are. In point of fact, they make an ornamental border for the skylight, it depends of course upon the proportion of your room to where those reflectors are placed.

If those reflectors were the only thing you had you would find your room dark in the center. You must, therefore, in addition to those reflectors, place your artificial lights over your skylights to give the general illumination of the room. You can project through your lower skylight, enough light from reflectors above to light your walls, but to do that is expensive and it does not give you the ease of control that you have, nor does it give you the big point that we are striving for in picture or other art object illumination and that is this: To have that object equally illuminated both as to the bottom and the top—the whole picture, let us say, to have an equal illumination—so that in the photometric test, you would find the same intensity of light at the top, bottom, in the middle and the sides, because that is the way that object was made, painted, woven or whatever the case might be.

As we know, and as the diagram which will shortly be shown to you graphically shows, when light starts out from a point, it spreads out and most reflectors do necessarily spread the light to give a wide enough path of that light to take in the entire picture and, as it spreads, the intensity diminishes and the consequence is that you have the top of your picture which is near the reflector over-illuminated and the bottom of the picture which is away from the reflector under-illuminated. What we do to overcome that is simple; there is nothing complicated about it. After months of investigation on the part of Mr. Champeau and myself of galleries and other places here and abroad and our experimental gallery (which we built up in the woods and tried out for three years with all kinds of devices) we merely put those things together so that they would work.

First of all, there is the lamp. That lamp is set in front of a reflector so that we get not only the rays from the lamp itself

(from the incandescent filament) but also coming back through the glass from the reflector behind it. Then they come to the prismatic glass which is in front of both the filament and, of course, the reflector behind the filament, and when it strikes that prismatic glass, the rays are brought together nearly parallel so that they come to the object in nearly parallel lines. Therefore, you have practically the same intensity and that means that in lighting your picture or your tapestry or your bit of furniture, or metal or your Chinese vase, you are giving that object the same intensity of light at its bottom, its side, its middle and every other part and without casting those deep shadows which you would get if you had a single source of light, because these reflectors are put in series, forming a continuous band of light (directed at the proper angle), about the room. Instead of having a light like this (indicating) which would throw a shadow to the left or to the right, you have them coming from both sides which makes the object stand out as the artist intended it to.

Well, that is the whole story. It is just as simple as anything possibly could be and you will see it, you experts, with your own eyes. It is just as effective with flat objects as it is with round ones.

The great sculptor of the Lincoln statue in the Lincoln Memorial in Washington, is pleading that we should do something like this with his figure down there, to the end that it might stand out as he designed it in his studio, and as he saw a small object stand out here. Our great dealers in art objects feel that now they have something which is simplicity itself.

I remember well, not so very many years ago, I was sitting in a little studio of an art dealer on Bond Street in London. He was pulling out picture after picture to show me. There was a dark Rembrandt that he had and he wanted all the light he could get on it. First he let one shade go, then another, to bring in all the light from the skylight. Pretty soon, he showed me a picture of a snowstorm. He pulled one shade, then another, to get a subdued light, because naturally the intensity for the dark Rembrandt was entirely too much for the snow scene.

Well, with our lighting, all he would have to do would be either to touch a button and have a little electric control which

would turn his louvers so that the light would be right or he could simply do as we do here, turn a little crank, and in a second's time, he would have the illumination that he wished.

It is nothing wonderful. There has been no great discovery. It is just a simple application of simple things which you men know a great deal more about than Mr. Lawrence X. Champeau and I have ever thought of knowing. But it has been done by coordinating the experience of one who has been brought up as I have, practically in an art gallery, with one who has been brought up with a great practical knowledge of light and lighting as one of our foremost photographers, and I deem it a rare good fortune that in being able to carry out these plans first of all, I, who had somewhat the genesis of the idea, should have had Mr. Champeau cross my path at a time when he could take up the development of these ideas and give them the practical application which they have been given, and latterly in having again come in contact with Mr. Harry Day, who as an architect knows proportions and distances and design, to take Champeau's ideas and my ideas and help us to give not only lighting which is at least the best yet, but also proportion of room and proper design so that we have an artistic and perfect home.

On behalf of the American Art Association, I welcome you here. I hope you will have a good time seeing not alone the lighting, but the exhibition. On behalf of Mr. Champeau, Mr. Day and myself, I trust that in this new system you will find something of interest and perhaps much of improvement.

DISCUSSION

L. H. Graves (Communicated): Inasmuch as the Grand Central Art Gallery lighting was also inspected on the evening of Mr. Kirby's paper on the lighting of the American Art Gallery and time did not permit of a description and discussion of the lighting of the former, it seems appropriate to offer a brief description of this work. In the Central Galleries there is no elaborate attempt at the control of daylight by the use of a system of louvres as described by Mr. Kirby, though because of the location of the galleries and the arrangement of skylights exceptionally good daylight is provided. The more interesting features are the several schemes of artificial lighting employed in the various individual galleries. There are schemes of direct skylight lighting with units

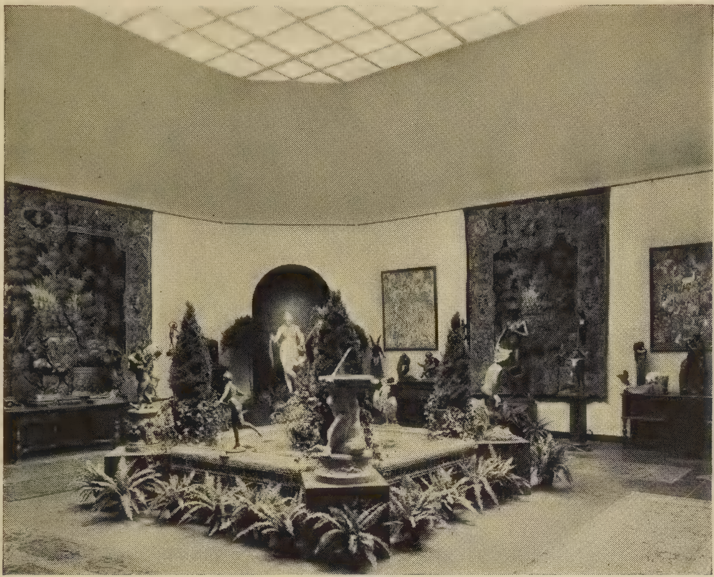


Fig. 5—Fountain room, Grand Central Art Galleries.

Fig. 6—Type of X-Ray reflector used for direct lighting.

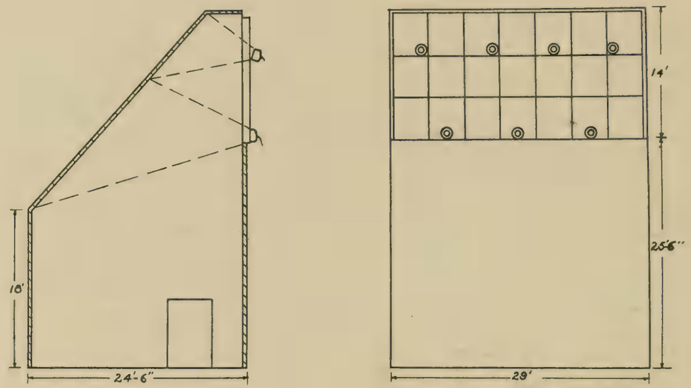


Fig. 7—Gallery F, Grand Central Art Galleries. Equipment used; seven 500-watt flood lighting units.

Fig. 8—Gallery F, Grand Central Art Galleries.

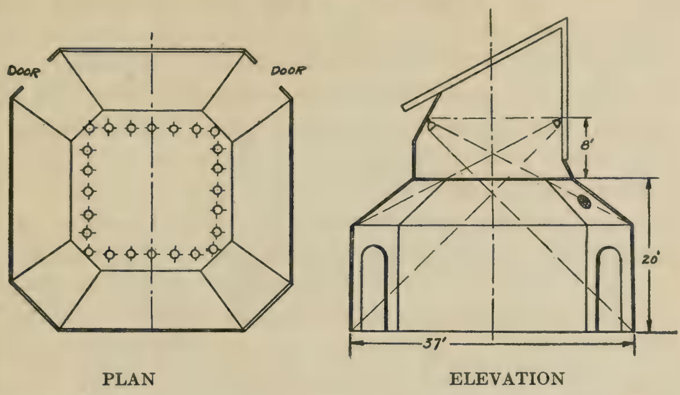


FIG. 9.—Fountain Room, Grand Central Art Galleries. Equipment used; twenty-four No. 33 X-Ray units with 200-watt Madza Daylight lamps.

designed to control and distribute the light as required, also schemes of indirect lighting in the smaller narrow galleries where no skylights are provided and also the rather unique application of flood lighting in one gallery where, with a vertical skylight, projector equipment is mounted outdoors in such a way as to flood the sloping ceiling opposite. This gave a system of diffused light in the gallery very much as when daylight is admitted.

In the fountain room (See Figures 5 and 9) and in the two galleries with the flat ceiling skylights, where the reflectors are mounted above for direct lighting, projector type X-Ray reflectors were used with 200-watt daylight Madza C Lamps. (See Figure 6) The units were located around the edge of the skylight and by use of the swivel joint mounting, were adjusted to direct the light on to the opposite walls. The incidental spill light, together with some diffusion caused by directing the beams through the skylights, gives ample general illumination in the room. The effect with the overlapping of light on the skylight and the use of the daylight lamps is very similar to that attained with daylight. It is indeed very pleasing and most successful for this type of interior. From twenty to twenty-four units were used over the skylight in each of these rooms.

In the smaller connecting galleries it was important to get a diffused artificial light high in intensity during the day time as well as at night, for, because of the construction of the building, it was

impossible to work in skylights. Total indirect lighting fixtures of simple design were used. Finished in a light tone to match the ceiling, the fixtures themselves are hardly noticeable.

In Figure 7 is shown section drawings of Gallery F in which the skylight was in one of the vertical walls. The location of the seven 500-watt flood lighting units is shown outside the room. As mentioned above the light is directed on to the sloping ceiling opposite and diffused over the entire interior. The effect is very pleasing and the results from a lighting point of view are entirely satisfactory. With the use of blue daylight lamps in the other galleries the effect was that of diffused north light, while in this gallery with the use of the 500-watt flood lighting lamps one might imagine the room flooded with warm diffused sunlight.

The equipment and scheme employed in the artificial lighting on this entire installation was so simple, yet the results so very satisfactory and so efficiently obtained, that I believe it offers an example which may be readily copied in many galleries old and new throughout the country that are now poorly lighted either because of the antiquated equipment or improper application.

AESTHETIC AND UTILITARIAN VALUE OF LUMINAIRES*

EMILE G. PERROT**

SYNOPSIS: In order to properly appreciate the aesthetic value of an object, it is necesary to have a clear understanding of the nature of beauty,—for mere sense gratification—amely of sight or hearing does not constitute the essential attribute of beauty.

According to ancient Greek philosophers, "beauty is a characteristic of any object comosed of various elements that produce a *unity* of effects upon the sensation of the beholder."

Now there are certain laws that seem to be followed by all works of painting, or sculpture, r architecture, that the consensus of opinion of mankind has judged beautiful. These laws eem to be in accordance with the working of man's mind, when he is striving to create somehing pleasing to his senses, and they may be grouped under three major heads, of Unity, Grace, and Proportion.

In designing luminaires, therefore, these laws should govern, and further, as the lighting ixtures should form an integral part of the whole architectural scheme, the illuminating engieer should have a knowledge of the architectural styles and periods, so that a method of ighting will be in harmony with the style of the room or building.

While there are certain problems such as the lighting of offices and factories, in which the bject of the light provided is purely utilitarian, and where the illuminating engineer has much ood work to do in providing efficient and serviceable conditions of illumination, there are igher fields for his activity in connection with the lighting of buildings of distinction, where esthetic and architectural considerations must prevail.

In my talk to you this evening on the subject announced, it s my purpose to treat it from the Architect's view point. Being concerned primarily with architecture, I am naturally interested n seeing that the element of beauty is maintained in all that pertains to making a building beautiful.

As all the fine arts have for their distinctive object the expression of the beautiful, it might be well for us to consider briefly what constitutes the beautiful, without investigating the philosophy of beauty.

An object admitted to be beautiful is one that is calculated to awaken a noble emotion. Mere sense, gratification, namely of sight or hearing, does not constitute the essential attribute of beauty. For instance, a painter may spread upon his canvas an array of meaningless colors, and however delicate the shades, if

*A paper presented before the Philadelphia Section of the Illuminating Engineering Society, March 14, 1922.

**Architect, Philadelphia, Pa.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by its contributors.

it is mere color and nothing more, we cannot call the result beautiful, neither can we call the single chord of music sounded upon an organ, though pleasing to the ear, beautiful.

The reason we cannot apply the epithet beautiful to such colors or sounds, may be best understood by the following comparisons—If we will consider how essentially different is the effect produced upon us by a painting of the seashore or a forest, and by the mere sense, gratification produced by any shade or combination of colors; or again, if we try to realize the difference between the effect of a Beethoven symphony and the pleasure given by a chord of music or succession of chords, we shall instantly realize that they belong to different categories.

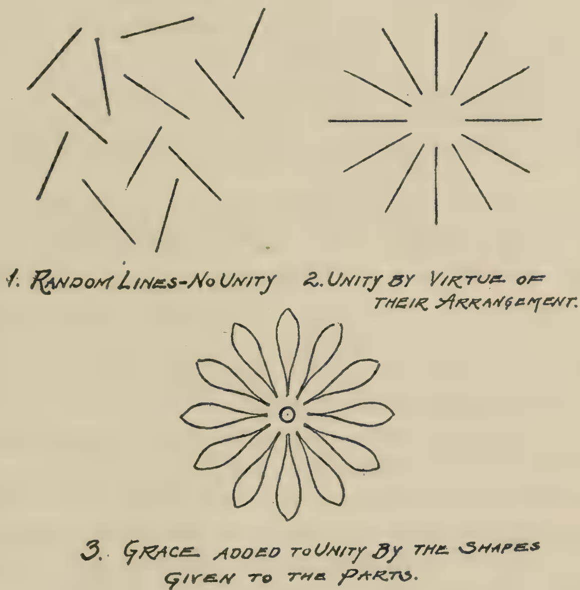
The difference is not merely one of intensity of pleasure, but that of the nature of the pleasure. The former is, properly speaking, beautiful; the latter is pleasing, but not beautiful in the strict sense of the term.

Now there are certain laws that seem to be followed by all works of painting or sculpture or architecture that the consensus of opinion of mankind has judged beautiful. Not only are these laws deducible in painting and sculpture and architecture, but the working of the same laws or others closely analogous to them can be found in good literature and good music. These laws seem to be in accordance with the working of man's mind, when he is striving to create something pleasing to his senses, or that has the quality of beauty, and they may be grouped under three heads—Unity, Grace and Proportion.

The first of these is so universal and so important that compliance with it has often been recognized as the sole necessity of beauty. Pythagoras and Aristotle voiced it in Greece over two thousand years ago, and almost every philosopher since has recorded it and restated it when dealing with the subject of beauty. Beauty, according to these authorities, is a characteristic of any object composed of various elements that produced a *unity* of effects upon the sensations of the beholder. This definition covers only a small part of the whole field of what men call beautiful; it neglects the entire emotional and associative value of beauty. It considers beauty merely as a matter of the senses rather than of the heart.

However, allowing all the onesidedness of this definition, it is found that Unity is fundamentally essential to beauty, and may be defined as the manifest connection of all the parts in a whole, being the quality of an object by which it appears as definitely and organically one single thing.

A simple illustration will make the meaning of Unity clearer. For example, draw twelve lines at random, as shown in the illustration, Figure 1,—there is no evident connection among them—there is no unity; but if they are drawn as in Figure 2, unity appears—they constitute a whole by virtue of their arrangement. If now, instead of straight lines, we give the parts shapes that are pleasing, we add grace, as in Figure 3.



Figs. 1, 2 and 3

By grace we mean that quality of form that produces in the human mind, through change of direction of the contour or outline of an object, the sense of perfect ease and consequent satisfaction.

Curved forms or outlines possess the characteristic of being more graceful than those composed of straight lines, the "S" curve is called the "curve of beauty" because its everchanging curvature is particularly fascinating.

The Greeks used it to the full, and along with it discovered the value of gradually changing the curvature in every line they used. There is scarce a Greek vase or a Greek moulding or ornament which has any circular curves at all, their outline starting in nearly a straight line, becomes more and more curved throughout its length, and finally ends in an abrupt curve. The inside curve of the thumb on your hand being a near approach to this outline.

This is in striking contrast with Roman mouldings and ornaments, which are always composed of circular curves.

Of equal importance to grace is the quality of proportion. Broadly speaking, this is the quality possessed by any object whose several parts are so related to each other as to give a pleasing impression. It is primarily a quality of the relationship of all the units in an object, rather than a quality of the units themselves. We will later see wherein this quality is manifest in our lighting fixtures.

While there are certain problems such as the lighting of offices and factories, in which the object of the light provided is purely utilitarian, and where the illuminating engineer has much good work to do in providing efficient and serviceable conditions of illuminations, there are higher fields for his activity in connection with the lighting of buildings of distinction, where aesthetic and architectural considerations must prevail.

If he really wants to be of great service to the architectural profession and to the community, he should understand how to adapt a method of lighting so as to be in harmony with the style of a room, its furniture, and the general scheme of decoration.

He should know something of the history of architecture, and the meaning of the traditions by which the Architect is guided.

He should appreciate the fact that the light provided must not only serve to illuminate the table, but to reveal panels, mouldings, ornaments and color.

If the illuminating engineer will study these things, his knowledge of the technical possibilities of the various illuminants, of shade and reflectors, etc., should be of great value. In the same

way, it may be conceded that some Architects do not appreciate sufficiently the aims of illuminating engineering, and it would be well for them too, to receive more information about illumination.

There are many instances in which the combined efforts of the Architect and the Illuminating Engineer would lead to great results and for the more important problems of lighting work co-operation of the two professions is necessary.

In my talk to you this evening I am going to emphasize the view point that considers the lighting fixtures an integral part of the whole architectural scheme, rather than attempt to go thoroughly into the details of the fixtures themselves.

So before considering actual installations, it will be well to have some understanding of the great architectural styles and the sub-division of these styles, known as periods.

It is customary, and indeed fitting, to commence the study of historic art with its beginnings in Egypt, although there has been left little of its influence in modern art. Here and there we find an example, such as the Egyptian Hall in Wanamaker's Store, which is a good example. The lotus plant is the principle natural motive used as a basis of the ornamentation of columns, etc. Walls and columns are decorated with a wealth of sculpture, symbolic or hieroglyphic in character fashioned within incised outlines or cut in low relief.

GREEK ART

The architecture, sculpture and painting of the people of Greek lands, who, gathering together the influences of Asia and Africa, developed a national art which marks the beginning of European civilization and culture. It was a style rich in beauty, yet keenly practical and full of originality, vigor, truth, intelligence, color, moderation and self-restraint.

The importance of Greek architecture in subsequent evolution cannot be over-estimated. Greek architecture is fundamentally the basis of all modern architecture, in that from it sprang the architecture of Rome, and from that later, the architecture of the Renaissance, which supplanted the Gothic idea.

In Greek architecture, furthermore, it is possible, for the first time, to perceive the origin of a multitude of architectural forms with which we are daily surrounded today—mouldings, ornamented motifs and the immortal "Greek orders" themselves—forms which

have come down to the present day, while those of ancient Egypt and Assyria did not live beyond the confines of their lands, or after the downfall of their empires.

The Greek evolved the "Classic Ideal" in architecture, an ideal of such purity and nobility and perfection that it has constituted the standard through the ages, and is today the fundamental of architectural design.

Greek architecture, elementally, is a column-and-lintel architecture, highly developed as time went on from the severest Doric orders to the most ornate Corinthian orders.

The names of the three orders are—Doric, Ionic and Corinthian. Each of them presents a different series of proportions, mouldings, features, and ornaments, though the main forms of the building are the same in all. The column and its entablature being the most prominent features in every such building, have come to be regarded as the index or characteristic from an inspection of which, the order can be recognized, just as a botanist recognizes plants by their flowers.

THE ARCHITECTURE OF ROME

The architects of Rome took Greek architecture and elaborated it, introducing in addition, and highly developing, the use of the arch.

The old Greek Doric order did not appeal to the sophisticated Romans, to whom it doubtless appeared too severe and too primitive. Their corresponding form was the Roman Doric column also called Tuscan. They made but little use of the Ionic, but appropriated and highly embellished the Corinthian.

Most characteristic of the Roman development of architecture was the combined use of column and arch, later a favorite theme for the architects of the Italian Renaissance.

Roman carving and ornamentation was rarely so refined or pure as similar work of the Greeks, but was usually more decorative. The Romans were lovers of inscriptions, and, in their architecture, began to pay more attention to secular buildings, both public and private, than had previously been accorded them. Public works, such as aqueducts and bridges, became architectural monuments, as well as theatres, baths, and triumphal arches, while the private residences, or villas, became luxurious and elaborate to a degree, and were filled with paintings, statuary, bronzes and other works of art, including Greek antiquities.

Architecture was fast coming into a closer relationship with the people, ceasing to occupy its earlier position of exclusive consecration to the gods.

There were Roman temples, to be sure, but there were an even greater number of Roman secular buildings which have played as important a part in the subsequent development of architecture as the earlier monuments of Greece.

BYZANTINE AND ROMANESQUE ARCHITECTURE

Before the final downfall and dismemberment of the Roman Empire in the year 455 of the Christian Era, with all the elaborate civilization it had developed, there grew up two types of church architecture which struggled on through the Dark Ages, sustained by the warmth of religious enthusiasm, and, in their way, keeping the lamp of architecture burning until times more propitious for its further development.

These two styles are known as Byzantine and Romanesque—the first of which, reaching a high development in itself, led to nothing else, and the second of which, by reason of its vital structural merits, grew directly into the great Gothic style, which was to completely fill the architectural stage until the coming of the Renaissance in Italy in the year 1400.

GOTHIC ART

In the eleventh century we see the beginning of that wonderful development of Gothic art which originated in France and was an outgrowth and refinement of Romanesque methods.

Gothic architecture is remarkable in that it is dually a structural architecture and a decorative architecture, with both of these essential aspects existent in equal proportions. The most important single thing to remember in considering Gothic architecture is that it may be closely likened to an organic growth. Its development was as natural and as consistent as the growth of a tree, rising up, putting forth branches, and these, in turn, putting forth leaves.

Let us endeavor to summarize the evolution of the Gothic church or cathedral, from its beginning in the vaulting achievements of the late Romanesque builders.

The typical plan took the form of a great cross, with three short arms and one long arm. The entrance was at the end of the long

arm, and gave access directly into the great central nave, flanked by side-aisles. The arms of the cross formed the transept, and a great tower rose at its intersection with the nave, or there were twin towers rising above the entrance front. The remaining arm of the cross was the apse, or sanctuary. There were other types of plan, but the cross was the most usual.

Architecturally, the plan was carried out with an intricate diversity of which only Gothic architecture could be capable. The walls of the nave, above the lower side-aisles, were carried on columns and pointed arches; the side-aisles, also arched and vaulted were supported, outside, by buttresses to take the lateral thrust. Above these, on the exterior, rose flying buttresses to take the thrust of the nave arches, and everywhere there was opportunity for pinnacles, turrets, grotesques, gargoyles, niches with images of saints, and all the profusion of Gothic detail. Within, the building was lofty and mysterious, richly and dimly lighted by tall, pointed windows fitted with stained glass—perhaps a magnificent rose window at the rear end of the nave. Everywhere, too, carved niches and holy images, intricate carving, dull color in polychrome or textiles.

Gothic architecture is often nicknamed "perpendicular architecture," which is reasonably descriptive, inasmuch as the horizontal entablature, with its frieze and cornice, forms no part of the Gothic idea, wherein all members mount ever upward, climbing one upon the other in one magnificent expression of altitude. Columns, arches, vaults, windows, pinnacles, buttresses, towers—all point upward—even the details of tracery and the niches for images point upward.

It is this sense of upward motion, reaching often to the heights of the sublime, which has made Gothic architecture essentially the architecture of the church, rendering, as it does, a remarkable expression of spiritual nobility in architectural terms.

The Gothic architecture of the important Northern countries can be sub-divided into three distinct styles—for instance, in England we have the style known as "Early English" or 13th Century Gothic. The next development was the "Decorated Gothic" (Fourteenth Century) and in the Fifteenth Century we have the style known as "Perpendicular," which is noted for a particular development of vaulting known as "fan vaulting."

The architectural style called the "Tudor" is to be applied to buildings under the reign of Henry VII, Henry VIII, Edward VI and Mary.

It was a transitional period, the flat-pointed arch was a conspicuous characteristic, and the Gothic forms of design were being gradually superseded by innovations of Italian Renaissance.

Following the Tudor style came the Elizabethan and Jacobean styles.

In France we see the same influences at work in the Gothic period, at the beginning of Gothic we have the fully developed Gothic rib vaulting in all its simplicity, corresponding to the Early English styles, the best example being Notre Dame at Paris. Then the fully developed 13th Century Gothic, which is the highest expression of Gothic art in the world, having for its examples such great cathedrals as Rheims, Amiens and Chartres, known as the Rayonnant (wheel-like). While the 14th and 15th Centuries, or late Gothic, deteriorated into an art of redundant detail, yet full of vigor and full of expression, called the Flamboyant (flame like), corresponding to the perpendicular style in England. So we can go through the same categories of style in other countries of Germany, Belgium and Spain.

RENAISSANCE ART

With the revival of the study of classic arts and letters in the Fifteenth Century, began Renaissance Art. Developing first in Italy, particularly in the City of Florence, it spread throughout the peninsula and eventually over all Europe and to America.

The Influences of classic study showed itself in the outlines and masses of the grandest churches, civic buildings, and in the humble details of the simplest home. Borrowing from Greece and Rome, the idea of the lintel, column arch, vault and dome, it applied these features sometimes structurally, but too often decoratively, and in its later developments with little taste and true architectural meaning.

In Italy the Renaissance architects used column and arch, or pilaster and arch, extensively, built splendid domes, and showed great fancy for surface decorations. Construction played a subsidiary part to design, as is evidenced by such frank expedients as the introduction of the rods between the supports of arches and vaults, to take the thrust, which could not be met in the design.

There was a general use of the Roman entablature, elaborate pediment and general profusion of ornamental detail. The so-called "Arabesque" decorations of the Renaissance pilaster is one of the most characteristic single details of the style. Another Renaissance design of frequent occurence is the statuary niche, with the upper portion in the form of a shell.

From Italy the style was carried to France, and the transitional style evolved was known as the style of "France I" or Francois Primier." The office building located at the S. W. Corner of 15th and Market Street is a very good modern adaptation of this style. To other countries in Europe the style was carried—to the Netherlands, Germany, Spain and England, developing in each country a peculiar style of its own, according as the national character found its expression. For instance, in Spain we find it strangely and richly blended with Moorish influence.

In England the Renaissance found its highest expression in the reign of Queen Elizabeth, so that the term "Elizabethan," when applied to a country house, is synonymous with the term "English Renaissance." The more important buildings of this period in England were distinctly formal and dignified, with little of the spontaneous diversity of the Italian Renaissance. Italian forms, however, constituted the basis of design, and deeply influenced all subsequent English architecture. The English Renaissance development of greatest interest today, by reason of its importance in the evolution of the modern country-house, was the Elizabethan manor. The country free from internal wars, the government powerful and protective, the element of defence became increasingly less in evidence. The houses became more livable, more comfortable and "modern" in character. Increased facilities for the manufacture of glass brought about the design of beautiful leaded windows. The interiors were rich in carved woodwork, and floor coverings came into use. The Elizabethan, or English Renaissance country-house, was an important step in the development of the country-house of today.

The decadence of Renaissance art is to be seen in the Rococo or Baroque development of the last three quarters of the Seventeenth Century. Ornament was developed to an extravagant and tastelessly disproportionate degree—architectural forms were distorted and preverted in a thousand fantastic and impossible

vagaries. Structural principles were ignored, and decoration was the main feature, not the embellishment of Baroque buildings.

It has been the habit of most architectural critics to sweepingly condemn all Baroque architecture, but such condemnation is neither intelligent nor merited. Granted that the style may be proved fundamentally illogical on many scores, it evolved many forms of permanent beauty and value, and was, if nothing else, an essentially decorative style, later developed along more rational lines in some phases of the French style of Louis XV. Despite the usual dismissal, then, of the Baroque or Rococo style as a mere architectural curiosity, entirely decadent, and even artistically immoral, it will be found more valuable to place it as a distinct expression of a peculiar idea, and an undeniably interesting page in the sequence of the architectural styles of the past.

In the latter part of the Eighteenth Century, a reaction from the extravagance of Baroque was inevitable. And the reaction took the form of the Classic Revival in France and in England. Some feeling of this revival manifested itself in this country even as late as the first two decades of the Nineteenth Century. And while there is at the present period no feeling in design so sweeping or general as to be called a "Classic Revival," Classic derivations are everywhere apparent, and almost invariably in such monumental buildings as are desired to express qualities of dignity and permanency, such as capitols, post offices, libraries, museums, banks, and the larger railroad stations.

THE CLASSIC REVIVAL IN FRANCE

Observation of the Classic Revival is best begun in France with a momentary survey of the progress of architecture immediately preceding the period of XIV.

The reign of Louis XIV came to a close in 1714 and the architecture of the period, as well as that of the preceding period, was pompous, elaborate, grandiose. Buildings of the time show a conflict between Renaissance order in design and Baroque extravagance, and all carried out in what was called (most appropriately) "The Grand Manner."

The succeeding period, that of Louis XV, is often called the "Rococo" period, because the "rock-and-shell" style reached its height at this time. "Louis Quinze work is practically synony-

mous with Rococo, the fanciful rock-and-shell curves that, like some fungous growth, invaded all branches of decorative art with amazing recklessness and rapidity." The characteristics of the period were distinct in their nature, though elaborate and various in form. Curved lines and intricate foliation appeared in all designs, and lack of symmetry was considered a desirable achievement. Importation of many works of art from China at this time added Oriental fantasies to the already fantastic Baroque-Rococo style, which grew increasingly extravagant throughout the reign of Louis XV. Much decorative work of the period is by no means without merit, but the style was too frivolous to effect any permanently great architectural expression.

Despite the intense interest in the Rococo style, its very extravagance finally became so wearisome and distracting that the reaction of the Classic Revival set in with the reign of Louis XVI (1774-1793), and Classic forms became increasingly popular until the close of the "Empire" period, in 1814.

THE CLASSIC REVIVAL IN ENGLAND

The Classic Revival in England commenced with the Georgian period (1714-1820) immediately following the Dutch influences of the reign of Queen Anne, and lasted, though waning somewhat in its Classicism toward the end, until the beginning of the Victorian era in 1837.

The Eighteenth Century Classic Revival in England reached its height during the reigns of the Georges, notably in the works of the Brothers Adam (1760-1820), in the reign of George III. The Adams, however, were not the first architects to design in the "Classic Taste."

Following Sir Christopher Wren and Inigo Jones, the great English Renaissance architects of the Jacobean period, William Kent, who died in 1748, produced works which were more in the nature of a "Classic Revival" than of the style of the Renaissance.

GEORGIAN COLONIAL IN AMERICA

With such widespread enthusiasm for Classic ideas in architecture in England, it is not at all surprising that this should have crossed the ocean to the American colonies, creating and moulding the style which should accurately be called "Georgian Colonial."

The "American Classic Revival" was a distinctly different development, coming, as it did, largely from France, and at a considerably later date than the Georgian Classic influences.

The Georgian Colonial types of American architecture took different forms in the North and the South, especially in the treatment of dwellings. In the North there is noticeable a great Georgian Classicism of detail, rather than of general form. New England doorways, windows and interior woodwork followed Classic formulae, rendering Palladian windows and Greek orders with an honest carpenter's technique. Independence Hall is one of the best examples of this type.

THE CLASSIC REVIVAL IN AMERICA

The American Classic Revival, as distinct from the Georgian Classic inspiration, came about largely through the development of friendly relations with France and the distaste for things English during the War of 1812. So closely allied, indeed, is this American Classic Revival to the contemporary style of France, that it has often been called "American Empire." The popularity of the Ultra-Classic left a number of interesting monuments in this country, of which, perhaps, the purest example is to be found in the old Stock Exchange Building, Dock and Walnut Streets, the Custom House, and grandest of all, the main building of Girard College.

Having thus reviewed the leading Historic styles, we will consider the aesthetic value of lighting fixtures to buildings of some of the great styles, noting the manner in which the fixture manufacturer has conformed the style of the fixtures to the architecture of the building.

The utilitarian aspect of fixtures, of course, is based entirely on the study of efficiency in illumination. Much effort has been put forth to obtain satisfactory results with the least expenditure of energy, and we are at once confronted with the claims of this or that special device or type of fixture as being superior to any other make.

The recent tendency of incandescent lamp manufacture has been toward high concentration of filament in quest of economy in current consumption. We may consider that the development has occurred in two stages. The first stage of lamps as represented by the carbon filament in vacuum bulbs are now considered extremely wasteful in the current they consume, yet they were in the early

days a scientific marvel and object of interest to the extent that they were hung about on stringers or mounted bare on chandeliers just as so many open flame gas jets. This might be called the age of bare lamps, and the glow from these carbon lamps was so mellow as to cause no discomfort to the eyes of the observers. Then came the second stage of lamps, which consisted of the tungsten metal filament in a vacuum bulb, and the intrinsic brightness as well as the economy in current consumption of the lamp unit was greatly increased. With this improvement various types of shades appeared for either protecting the eyes from the direct rays of the lamp or concentrating it for particular uses, so that now some type of reflector is essential for proper light diffusion. With the advent of the nitrogen gas filled bulb with its high candle power and economical current consumption, the problem of diffusion was solved by the invention of reflectors, so shaped that the concentrated rays of the lamp are split up and scattered, thus producing a soft light.

Without attempting to discuss the merits of any particular type of lighting unit, a consideration of the more popular and meritorious ones will be in order. The illustrations I am about to show you have been obtained in most instances through the courtesy of the various fixture manufacturers, and without their co-operation I should have been unable to make the presentation of the subject as thorough as it is.

The simplest method of obtaining high efficiency in direct lighting is with the single unit of sufficient intensity and proper diffusing reflector, to give as near uniform conditions of lighting as is possible with artificial illumination.

I show on the screen views of interiors of buildings in which the various types, all known to you, are used. The installations are supposed to represent what is good practice with each type, so that it is possible to judge of the architectural value of the fixtures as well as the utilitarian.

The Americolite Company's single unit is a very artistic luminaire, asare also those of the Brascolite, in their various treatments as to styles to harmonize with the architecture of the building, as the illustration of the lobby of the Hotel Marion, Little Rock, Arkansas, shows. See figure 4.

Fig. 4—Luminaires in Lobby, Hotel Marion, Little Rock, Ark.

Fig. 5—Roman Catholic Church of Gesu, Philadelphia, Pa.

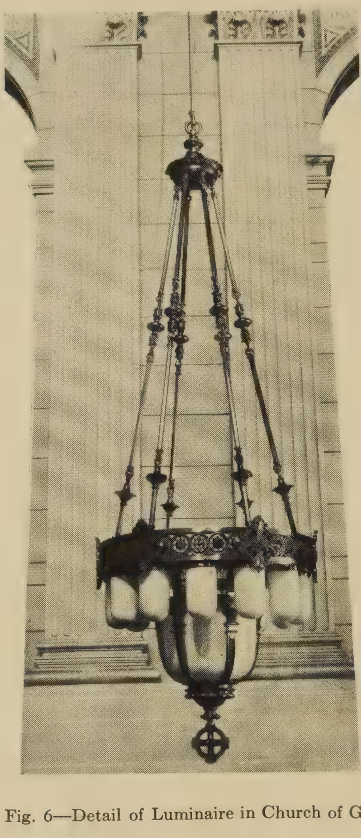


Fig. 6—Detail of Luminaire in Church of Gesu.

The Celestalite unit also can be obtained in simple designs or more ornamental ones, to conform to the architecture of the building, as shown by the illustrations.

In considering lighting installations in churches, two distinct methods of lighting are at hand—indirect or semi-indirect. The installations of indirect lighting in the Eberhart Memorial Church, Mishawaka, Indiana, is a notable example of an indirect system in which the architectural style has been carried out in the fixture, the style being Gothic, National X-Ray Reflectors being used.

The Cathedral of St. Helena, Helena, Montana, is a very good example of indirect lighting, supplemented with direct light from concealed X-Ray reflectors inserted in the crown of the vaulting.

The use of standards with X-Ray reflectors for lighting show rooms, stores, hotel lobbies, etc., is well exemplified in the lighting scheme of the Commodore Hotel, New York.

The second method of lighting churches, that is, by the semi-indirect method, is well exemplified in the installation recently completed at the Roman Catholic Church of Gesu, Philadelphia. The Church is one of the largest in the country, having a nave vault 100 feet high and 78 feet clear span, and a length of 147 feet. The original lighting consisted of side wall gas brackets and electric standard on the pew divisions, a very unsatisfactory scheme. This has all been superseded by ten large luminaires, hung from the vaulting, the bottom of which are 30 feet from the floor. The chandeliers are arranged in two rows, 46 feet apart, with the fixtures spaced 22 feet from each other on each side. Each fixture has 1400 watts, arranged with one large central unit of 500 watts and twelve small ones of 75 watts each. The average foot-candle illumination is about 1½ foot-candles, and is very evenly distributed, the maximum being 1¾ foot-candles. The building is more than amply illuminated at this intensity, there being no doubt that with a lower foot-candle intensity the illumination would be satisfactory. Each fixture is controlled with two separate circuits so that it is possible to distribute the lighting at will, according to the needs. See figures 5 and 6.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

THE PRESENT STATUS OF VISUAL SCIENCE*

BY L. T. TROLAND**

The Monograph, "The Present Status of Visual Science," recently published as a Bulletin of the National Research Council, is officially the product of the Monograph Sub-Committee of the Committee on Physiological Optics of the Council, although the present writer must acknowledge responsibility for its contents and form.

A word may first be said concerning the Committee on Physiological Optics. This committee was the outcome of an original conference held between Dr. Augustus Trowbridge, then chairman of the Division of Physical Sciences of the Research Council, and Professor F. K. Richtmyer in Chicago early in 1921. Suggestions there developed recognizing the need of a survey and coördination of work in the field of physiological optics, took concrete form in a meeting of a group of men interested in the subject in New York shortly afterwards. This meeting resulted in the formation of a formally authorized committee consisting of Mr. Adelbert Ames, Professor W. T. Bovie, Dr. P. W. Cobb, Mr. L. A. Jones, Dr. W. B. Lancaster, Dr. P. G. Nutting, Mr. I. G. Priest, Professor J. P. C. Southall, Dr. L. T. Troland and Professor F. K. Richtmyer, chairman. The committee held numerous meetings during 1921 and 1922 and discussed problems relating to the progress of visual science. Valuable conferences were held between the committee and other groups of scientists interested in optics, physiology or allied subjects, one of the meetings being at Woods Hole and another at the Harvard Medical School. One of the most important practical results of the work of the committee consisted in the forma-

*Research Council Monograph.

**Dept. of Psychology, Harvard University, Cambridge, Mass.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

tion of a section of the Optical Society of America relating to physiological optics and guaranteeing the inclusion in the annual program of this Society of a considerable number of papers dealing with this subject. Another very important enterprise which is at present under way under the editorship of Professor J. P. C. Southall is the translation into English of Helmholtz's great Handbook of Physiological Optics; an enterprise which is officially sponsored by the Optical Society, but the initiation of which may be attributed to the Research Council Committee. A third undertaking was the preparation of the Monograph to which the present note refers.

The purpose of this Monograph was to outline briefly the general field of research denoted or connoted by the term "physiological optics," to evaluate the present state of knowledge in this field, and, if possible, to suggest the most profitable lines for future research. In spite of the relatively small scope of the subject in comparison to the whole body of science this project was so ambitious a one that it could scarcely be carried through with any hope of perfection of execution. However, an attempt was made to sketch the situation in a way which may prove helpful to those interested in the subject.

It is a striking feature of visual science that it involves in an almost equally balanced degree the three separate sciences of physics, physiology and psychology, so that workers upon visual problems are nearly always hindered by lack of acquaintance with one or more of these general subjects. The Monograph in its published form attempts to combine the various factors derived from physical, physiological and psychological studies into a coherent system and to show how researchs undertaken from seemingly discrepant points of view may fit together harmoniously. No attempt is made to summarize established facts in detail, although in each department of the subject the discussion is made sufficiently concrete to render the argument substantial. The principal purpose of the brief summaries of extant results is to reveal the vacant spaces which exist between them and thus to indicate needed lines of research.

The Monograph is divided into five chapters. The first chapter deals with the position of visual optics among the sciences, including a brief historical sketch to establish the necessary perspective, this sketch being followed by a study of certain general

characteristics of present visual knowledge, including its peculiar weaknesses. The second chapter deals with the fundamental conceptions and methods of visual science. An attempt is here made to specify the ultimate factors in the problem of vision, including an analysis of the general physiological system which is involved, its relation to the stimulus and to consciousness. The principal methods, psychological, physiological and physical, which are available to the visual investigator are next considered, and the final section of the chapter deals with the utility and requirements of theories in visual research.

The last three chapters of the Monograph are concerned with concrete problems in the science. Chapter III considers problems in the analysis of visual experience, or the purely psychological aspects of the subject. In this chapter a discussion is offered of the system of colors, regarded as psychological qualities, together with color nomenclature. The general properties of the visual field and of visual space are also outlined, important lines of research being suggested in connection with both of these general topics. The fourth chapter deals with the physiological and other physical factors in vision reviewed entirely apart from their psychological or conscious concomitants. This chapter contains six sections dealing in order with visual objects and stimuli, the dioptric and allied processes of the eye, the retinal stimulation, the afferent nerve excitation and conduction, the central processes in vision, and oculomotor mechanisms. Under each of these topics there is a sketch of existing knowledge combined with suggestions for further research.

The fifth and last chapter deals with the salient problems of visual psychophysiology, which concern relations between the psychological and the physiological factors discussed in the two preceding chapters respectively. The psychophysiological problems are divided as follows: brilliance vision, chromatic vision, form vision, motion vision, visual relations essentially involving time, visual relations essentially involving pattern or position, and the explanation of visual psychophysical correlations. In this chapter, as in previous ones, facts are outlined mainly for the purpose of suggesting the gaps which exist between them. The writer makes no pretense to complete comprehensiveness or accuracy in the presentation of facts or problems, although he has attempted to cover the field in as adequate a way as is possible within the scope of 120

pages. The references to literature number 268, but literature subsequent to the year 1920 is not considered. The discussion is limited primarily to human vision.

It is hoped that the above comment may serve to bring the Monograph to the attention of members of the Illuminating Engineering Society and others who are interested in the progress of knowledge concerning vision.

GLARE AND ITS RELATION TO EYE SIGHT CONSERVATION*

BY F. C. CALDWELL**

I am very pleased to come into this movement for eye-sight conservation, and I hope to bring to the work some advantage because of my connection with illuminating engineering.

When our Director asked me to speak, it seemed that it might be best to pick out one phase of the relation of illumination to eyesight conservation and to dwell on that in the hope that those of you who have not given much thought to this relation may have firmly fixed a few definite ideas.

That good illumination is one of the most important factors in the conservation of eyesight is a truism as old as the hills. I doubt not that among the earliest recollection of all of us are admonitions against reading in insufficient light and instructions concerning the direction from which the illumination should come. Indeed such admonitions and instructions indicate two of the three most important defects found in lighting—that is inadequate illumination and improper distribution. We were also told in our earliest years not to look at the sun, and without reflections upon the sun as an illuminant, there was indicated the third and perhaps the most serious of the defects of bad lighting—glare.

It is because glare is not only the most common and serious defect in lighting at the present day, but also because it is the least

*Address delivered before the Eye Sight Conservation Council, Feb. 6, 1923.

**A.B., M.E., Professor of Electrical Engineering, Ohio State University; member of Council, Illuminating Engineering Society; member Board of Directors, Eye Sight Conservation Council.

understood, that it has been chosen as the subject of the paper which I am to have the pleasure of giving this evening.

Before examining in detail the problem of glare it will be well to remind ourselves of some of the facts concerning the development of illumination. Lighting is one of the oldest of the human arts, but until recently one of the slowest to develop. So far as their characteristics as light-sources were concerned, there was very little difference between the candles or whale-oil lamps of our grandmothers and the selected fagots of the cave dwellers of fifty-thousand years ago. Even the gas and kerosene oil flames of the end of the last century, even carbon incandescent lamps were only a little larger and a little brighter. But the curve of development which for so many milleniums had run along almost horizontal, was commencing to trend upward and since the beginning of the present century with the development of the tungsten filament and the gas-filled lamp, it has risen even more sharply. One can safely say that in the past half century there has been more development in lighting than in all the ages before since man first picked a brand from the fire to light his way.

These facts of history are brought out to emphasize the magnitude of the task which lies before us in becoming accustomed in so short a time to these enormous changes in the condition of lighting. The three most striking differences in light sources that have come to pass are—greatly increased light-flux or candlepower, greatly increased brightness and greatly reduced cost, thus making possible very widely extended use of artificial light, and at the same time vastly magnifying the problems involved in its application. This extension of artifical illumination has brought with it a burden for the eye, which all too quickly it must learn to bear.

This is a point which should be particularly emphasized, the human eye has gone along through countless years, with little change in what was demanded from it. It worked through the daytime, for the most part looking at rather large objects, and when it became dark, it generally ceased to function. Now, within just a few years this has all changed. The use of the eye for fine work, for reading and for fine manufacturing operations, has been very greatly increased and then in addition, we are demanding that it do much of its work under artificial light which, furthermore, in many cases is far from good.

The change of lighting facilities has been so sudden, that men, trying to use the new illuminants in the same way that they have used the old thru countless generations, are likely to produce bad results. Of old, the problem of lighting was little more than the problem of getting the work near enough to the puny flame so that it could be seen, and few and far between were those who did work which needed even so much light. It is not strange, therefore, that many make sorry work of it when they set out unaided and without study to provide themselves with the new light.

The importance of glare has been recognized by regulations against it in the industrial and school lighting codes, drawn up by the Illuminating Engineering Society and followed more or less closely in the laws of several states.

Glare is not an easy phenomenon to define. It will perhaps be best to study first its different forms and characteristics and then to sum up our observations in a definition. The magic number "three" runs thru this subject in a rather remarkable way. We have already observed three changes in light sources and three defects in lighting. Now we may note three elements in the production of glare. These are excessive brightness, excessive volume of light flux and excessive contrast.

Though excessive brightness is probably the commonest and most generally recognized source of glare, the other two are also deserving of careful study. The seriousness of glare from too great brightness has enormously increased during recent years on account of the introduction of the tungsten filament lamps, especially the gas-filled type with spiral filament. Even the earlier lamps were too bright to make their use without screening devices desirable, but the consequences of operating the present types in this way are quite intolerable except where the lamps are hung very high. Even where globes or deep reflectors, which hide the lamps, are used, consideration must be given to the quality of the glass. If it is of too low a density, the brightness may still be too great for safety and comfort to the eyes. On the other hand many kinds of glass which are dense enough to cut down the brightness adequately, absorb too much of the light. The best makes of glass available when used in large enough globes, pass about eighty percent of the light while still sufficiently reducing the brightness. With the right kind of glass the brightness decreases as the size of the globe increases. Thus a 100-watt lamp in a 14-inch globe

would give so low a brightness as to be satisfactory for any location, while the same lamp in a 6-inch globe would give a brightness about equal to that of the clear sky and would be at about the limit even when placed well up in the room where it would not constantly come into the field of vision of the occupants. With some types of diffusing glass, the brightness is not uniform, but is greatly increased at a spot in line with the filament. In such cases the above reasoning does not hold and the maximum brightness must be reckoned with.

The second source of glare, that is excessive volume of light flux, is likely to occur wherever powerful light sources, even of comparatively low brightness are in the field of vision and close to the observer. The influence of amount of flux on glare is also shown in the fact that a large light of a given brightness will be more glaring than a small one of the same brightness. On one occasion the writer experienced a quite uncomfortable case of this type of glare when at a birthday party, the hostess seated the guests at small tables with a birthday cake carrying a number of candles in the center of each table. While the brightness was low and the total light flux was not large, the fact that its source was so near, resulted in a relatively large entrance of flux into the eyes. The familiar cases of glare from a window, opening to the sky and of reflection from snow and water also involve the element of large light flux.

Glare of the third type—that due to excessive contrast, is well illustrated by the difference between the glare from an automobile headlight in the daytime amid bright surroundings, giving little contrast and the same light at night, when surrounded by black darkness, with a maximum of contrast. A window which, placed in a white wall, might cause no discomfort, might become trying if the wall were painted a dark color. Again a luminaire so designed as to light up the ceiling around it may not appear glaring, while another of the same brightness which leaves the ceiling dark may be trying to the eyes.

In this discussion the three sources of glare have been considered separately, and it is indeed possible to produce glaring conditions where only one of the above causes is present in a notable degree. On the other hand it is very common to find two of these causes present or even all three in a single instance of glare.

Having given a source of glare, due to either of the above causes, there are three conditions not associated either with the light source itself nor the condition of the eyes which determine its seriousness to an observer. These are first the angle which the source of glare makes with the line of vision of the observer. Thus if light is nearly overhead no glare will be experienced, no matter how bright or how large it may be; then as the angle decreases the unpleasant sensation increases till, when the eye is directed toward the source of glare the effect will be at its maximum. It is also true that for a given angle the glare is greatest if the light is below the eye and least when it is above. For the latter case the effect of the glare is not generally serious except for large and bright light sources, when the angle between the light and the line of vision is greater than 30 degrees. The line of vision is generally taken as horizontal, for while it may be directed downward for work, it generally reaches the horizontal frequently for rest or for distant vision.

The second condition determining the seriousness of glare is the distance away of the light-source. It is quite obvious that at a sufficient distance, any source of glare would cease to be trying. The effect of the third condition is equally obvious, namely, the period during which the eye is exposed to the glare. Thus any case where the exposure is continuous is much more troublesome than one where it is intermittent, with short periods of exposure.

Evidently the seriousness of any case of glare will be largely determined by the condition of the eye as to pupillary area and other circumstances affecting its sensitiveness. The glare upon coming into a brightly lighted room from the dark is a familiar experience.

When we consider the effects produced by glare we find another of our series of trinities. These effects are temporary impairment of vision or blinding, discomfort, and eye fatigue, often leading to injury. Impairment of vision comes both from the reduction of the pupillary area and from the direct effect of the light entering the eye. It is often more serious than is ordinarily realized. The discomfort, which protects the eye by compelling it to turn away from the sun or other excessively bright lights is an important natural safety measure. It is however generally the light of lesser flux or brightness which is not so

readily recognized as a source of glare, that is most likely to cause fatigue and injury to the eyes.

To complete this discussion of glare, mention should be made of a special though common and important case, namely, glare due to reflection from polished surfaces. As such reflections generally come from below, their effect is magnified by the greater sensitiveness of the eye to light from this direction. Common cases of this are reflection from bright materials upon which work is being done, glass or polished wood table tops and glossy paper. In the latter case an effect is produced which is known as veiling glare. The bright light reflected from the surface of the paper to the eye largely masks that coming from the type and greatly increases the eye strain involved in reading. Much effort has been made in recent years to encourage the use of paper with a mat surface, especially in school-books, so as to reduce this troublesome phenomenon.

It will now be in order to attempt a definition of glare. Perhaps as good a one as any is that "glare is any condition of light entering the eye which produces blinding, discomfort or injury." Glare has also been tersely defined as "light out of place."

From what has been said it will be readily understood that glare, unlike intensity of illumination, is not easy to measure, nor can very satisfactory specifications be drawn up as to permissible limits. A fairly successful approximation to such specifications has, however, been made in recent editions of the industrial lighting codes mentioned above. Here cases of potential glare have been classified according to harshness into ten grades. These grades depend upon combined candlepower and brightness and upon the type of luminaire or light source. Then tables are given showing the grade of potential glare permissible in different kinds of lighting and in different positions relative to the eyes of the workers.

To sum up the discussion of glare then, we have the following group of trinities:—

Three defects of lighting—inadequacy, bad distribution and glare.

Three elements in the production of glare—excess of brightness, excess of light flux or excessive contrast.

Three conditions determining the seriousness of glare—angle above the horizontal, distance away and period of exposure.

Three effects of glare—blinding, discomfort and fatigue or injury.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW ENGLAND Meeting—May 11, 1923

At the May meeting of the New England Section which was held on the evening of May 11 at the Industrial Lighting Exhibit in the Rogers Building, Mr. Guy Lowell presented a paper, "Illumination from the Architect's Point of View."

For some time it has been apparent that some method should be evolved whereby the viewpoint of the architect on illumination might be interchanged with that of the illuminating engineer. There has often been an unfortunate tendency to consider the illumination and lighting outlets for buildings as incidental details, and to solve the problem by rule of thumb or mere routine, often to the neglect of the wonderful utilitarian and aesthetic values of high grade lighting. On the other hand, there is tendency of the lighting engineer to lose sight of the aesthetic side of illumination in his desire to provide an efficient installation from the engineering point of view.

From the standpoint of lighting, Mr. Lowell divided buildings into two classes, those built for commercial or industrial purposes and those built for recreation. In the commercial or industrial building, the architect is glad to accept the advice of the engineer regarding the lighting. In buildings erected for recreation, such as museums, residences, etc., Mr. Lowell hoped that some method would be evolved whereby the engineer might more closely absorb the ideas of the architect and install lighting in accordance with the general artistic treatment.

Many problems and their solution were related, several of them being quite daring and spectacular. In the Boston Museum of Fine Arts it was found desirable to install a window equipped with artificial daylight to obtain the proper effect in a display located some distance from any windows. The interest and upkeep on the artificial window was found to be much less than if an actual window were constructed.

At the close of the talk an interesting discussion was held in which representatives of the fixtures houses took part. There were in attendance about fifty members and guests.

PHILADELPHIA Meeting—May 17, 1923

The Philadelphia Section met at the Engineers' Club on the evening of May 17 to hear a paper, "Modern and Spectacular Lighting" presented by Mr. W. D'Arcy Ryan, Director of the Illuminating Engineering Laboratory of the General Electric Co., Schenectady, N. Y.

In view of the general and popular interest in the paper the section observed "Ladies' Night." Preceding the meeting dinner was served to fifty members and guests at the Arcadia Cafe.

Mr. Ryan described the lighting effects at the Panama-Pacific Exposition and also the illumination of the Brazilian Centennial Exposition held during the past winter at Rio de Janeiro. The paper was especially interesting on account of the approaching Sesqui-Centennial Exposition to be held in Philadelphia in 1926, and was illustrated by a large number of lantern slides.

Col. John Price Jackson, Chairman of the Sesqui-Centennial Committee also spoke on behalf of the proposed exposition and showed slides of the Centennial Exposition which was held in 1876 at Philadelphia. There were in attendance one hundred and seventy-five members and guests at the meeting.

NEW YORK Meeting—May 11, 1923

A joint meeting of the New York Section and the Northern New Jersey Chapter was held in Paterson, N. J., on the evening of May 11. Preceding the meeting dinner was served to sixty-five members and guests at Faust Restaurant which was followed by an inspection of the lighting installation of the Cooper Hewitt Mercury Vapor lighting system in use at the National Silk Throwing Co. of Paterson.

The meeting was held in the Chamber of Commerce Rooms and two interesting papers on silk mill lighting were presented. Mr. W. J. Winninghoff read a paper, "Silk Mill Illumination with Mercury Vapor Lamps" by Mr. C. F. Strebig, Cooper Hewitt Electric Co., Hoboken, N. J., and Mr. H. W. Desaix, Watson-Flagg Engineering Co., Paterson, N. J., presented a paper, "Silk Mill Illumination with Incandescent Lamps."

There was considerable discussion of the papers and the attendance eighty-five members and guests.

NORTHERN NEW JERSEY Meeting—June 11, 1923

A joint meeting of the Newark Master Electricians' Association and the Northern New Jersey Chapter was held on the evening of June 11 at the Eagles' Home in Newark, N. J.

The meeting was addressed by Mr. S. G. Hibben, Manager of the Illumination Bureau of the Westinghouse Lamp Co., on the topic, "Practical Electric Lighting." In presenting the subject, Mr. Hibben discussed the following points: Light, and how it is measured; Characteristic distribution of light from various types of luminaries; Planning lighting installations; and the Value of good lighting.

There were eighty-six members and guests in attendance at this joint meeting and a general discussion was held by the members and guests present. A rising vote of thanks was tendered Mr. Hibben for the presentation of the talk.

TORONTO Activities

At the Toronto Chapter meeting on March 26, Mr. G. G. Cousins of the Hydro Electric Power Commission gave an interesting talk on "Characteristics of Glassware."

Mr. F. T. Groome presented a paper, "Difficult Problems in Illumination" before the chapter on the evening of April 23.

The annual meeting was held on May 28 at which the following officers for the coming year were elected: Chairman, Mr. W. H. Woods; Secretary, Mr. J. T. Scott; Executive Committee, Messrs. R. D. Albertina, R. M. Love, W. Orr, and G. R. Anderson, ex-officio.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council, May 10, 1923, the following were elected to membership:

Six Members

BAYLISS, ROGER V., American Gas Accumulator Co., Elizabeth, N. J.
CROSBY, JOSEPH G., Whalen Crosby Electric Co., 140 N. 11th St., Philadelphia, Pa.
ELLIOTT, E. LEAVENWORTH, Cooper Hewitt Electric Co., Hoboken, N. J.
HOBBS, LEONARD A., St. Louis Brass Mfg. Co. & Brascolite Co., 1331 W. 7th St., Los Angeles, Cal.
TAGGART, RALPH C., Dept. of Architecture, Capitol, Albany, N. Y.
VAN GILLUWE, FRANK, Western Electric Co., 301 E. 8th St., Los Angeles, Cal.

Sixteen Associate Members

BALKAM, HERBERT H., Consumers Power Co., 252 W. Main St., Jackson, Mich.
COLLAR, OLCOTT N., Sargent & Lundy, 1412 Edison Bldg., Chicago, Ill.
DESKINS, HIRAM T., Kilgore Electric Co., Box 371, Williamson, W. Va.
ETESON, FRANKLIN C., Blackstone Valley Gas & Elec. Co., 231 Main St., Pawtucket, R. I.
FLOWERS, DEAN W., St. Paul Gas Light Co., 51 E. 6th St., St. Paul, Minn.
GLAMEYER, WILLIAM, JR., United Electric Light & Power Co., 514 W. 147th St., New York, N. Y.
GROSSBERG, ARTHUR S., Albert Kahn, 1000 Marquette Bldg., Detroit, Mich.
HALE, H. S., Westinghouse Elec. & Mfg. Co., 717 S. 12th St., St. Louis, Mo.
LOCKER, FRANK H., Detroit Edison Co., 2000 Second St., Detroit, Mich.
MATCHETT, FRED D., Victor Electric Supply Co., 131 Jefferson Ave., E. Detroit, Mich.
QUIVEY, WYLLIS E., Benjamin Electric Mfg. Co., 847 W. Jackson Blvd., Chicago, Ill.
ROBINS, ORRIN A., Electric League of Columbus, 9 E. Long St., Columbus, O.
STREBIG, CHARLES F., Cooper Hewitt Electric Co., 95 River St., Hoboken, N. J.
TIMM, EDWARD W., Western Electric Co., 458 Milwaukee St., Milwaukee, Wis.
TURNBULL, T. S., Tallman Brass & Metal, Ltd., Wilson St., Hamilton, Ont., Canada.
WAGSCHAL, GEORGE, George D. Mason & Co., 508 Griswold St., Detroit, Mich.

One Transfer to Full Membership

MAHAN, HOWARD E., General Electric Co., Schenectady, N. Y.

The General Secretary reported the death, on April 22, 1923, of one associate member, C. N. Jelliffe, American Light and Traction Co., New York City.

CONFIRMATION OF APPOINTMENTS

As members of the Committee of Tellers—E. L. Bradbury, Chairman; D. W. Atwater, R. H. Maurer, H. H. Millar, and A. S. Turner.

As members of the General Convention Committee—Henry W. Peck, Vice-Chairman; H. E. Mahan, Secretary; Alexander Anderson, H. Calvert, Julius Daniels, E. Y. Davidson, Jr., Frank H. Gale, S. G. Hibben, Preston S. Millar, G. Bertram Regar, W. M. Skiff, J. L. Stair, G. H. Stickney and E. D. Tillson.

As member of the Committee on Research—Ernest F. Nichols.

The Council accepted with regret the resignation of Dr. Edward P. Hyde as Chairman of the Committee on Research.

The Council accepted the report of the Committee on Time and Place, designating the Convention headquarters at the Fort William Henry Hotel, Lake George, N. Y., September 24 to 28, 1923.

The Council approved the amendment of By-law (a), Section 1, Article IV, of the Constitution to read as follows: The entrance fee for Members and for Associate Members shall be $2.50. Remittance for entrance fee and current dues shall accompany the application.

At the meeting of the Council, June 28, 1923, the following were elected to membership:

Three Members

Curtis, Kenneth, National X-Ray Reflector Co., 235 W. Jackson Blvd., Chicago, Ill.

Gould, Herman P., Eastman Optical Shop, Inc., 12 Maiden Lane, New York, N. Y.

Odenath, Harry E., Sears Roebuck & Co., 4640 Roosevelt Blvd., Philadelphia, Pa.

Twenty-two Associates

Besinsky, Vaclav, Czechoslavak League of Electrotechnics, 1 Palackého Ulice, Prague VII, Czecho-Slovak Republic.

Brown, Willard C., National Lamp Works of G. E. Co., Nela Park, Cleveland, Ohio.

Domoney, Earl R., Consumers Power Co., 134 S. Washington St., Saginaw, Mich.

Donahue, Rev. Joseph N., Columbia University, Portland, Ore.

Dunn, J. M., Radio Appliance Co., 123 Pleasant St., Morgantown, West Va.

Fleming, E. F., Central Electric Co., 316 W. Wells St., Chicago, Ill.

Gray, Samuel McK., Electrical Testing Laboratories, 80th St. & East End Ave., New York, N. Y.

Haas, O. F., National Lamp Work of G. E. Co., Nela Park, Cleveland, Ohio.

Hannum, J. E., Eye Sight Conservation Council of America, 1206 Times Bldg., New York, N. Y.

Hartman, Harris V., New York Edison Co., 130 East 15th St., New York, N.Y.

Hill, Marvin, Benton, Kansas.

Hinton, James W., Westinghouse Lamp Co., 1005 Market St., Philadelphia, Pa.

Humez, J. F., Macbeth-Evans Glass Co., 5-134 General Motors Bldg., Detroit, Mich.

Humphrey, Arthur F., Biddle-Gaumer Co., 3846-56 Lancaster Ave., Philadelphia, Pa.

Johnston, Richard J., George Cutter Works of Westinghouse Elec. & Mfg. Co., South Bend, Ind.

Kase, Daniel B., Rumsey Electric Co., 1007 Arch St., Philadelphia, Pa.

Laughton, Abbot A., Athol Gas & Electric Co., 426 Main St., Athol, Mass.

Mausk, Raymond E., National Lamp Works, Nela Park, Cleveland, Ohio.

Nichol, H. G., Jr., Macbeth-Evans Glass Co., Chamber of Commerce Bldg., Pittsburgh, Pa.

Norris, George T., Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.

Wilson, Elmer D., 209 Clinton Avenue, Newark, N. J.

Wise, John E., University of Wisconsin, Madison, Wis.

One Associate Member Reinstated

Kato, K., Tokio Electric Co., Kawasaki-Machi, Kanagawa-Ken, Japan.

One Transfer to Associate Membership

Trimming, Percy H., Dominion Flour Mills, Ltd., Montreal, Canada.

The General Secretary reported the deaths of two members and two associate members: Dr. Louis Bell, 120 Boylston Street, Boston, Mass.; Professor A. G. Webster, Clark University, Worcester, Mass.; and Mr. Uhl M. Smith, Bureau of Standards, Washington, D. C.; Mr. C. A. Strong, 79 Milk Street, Boston, Mass.

CONFIRMATION OF APPOINTMENTS

As members of the General Convention Committee—N. R. Birge, B. S. Beach, W. T. Blackwell, S. H. Blake, A. D. Cameron, S. E. Doane, W. L. Robb, C. P. Steinmetz, C. D. Wagoner, D. B. Taylor, H. F. Wallace, F. H. Winkley and L. A. S. Wood.

As member on the Advisory Committee, Engineering Division, National Research Council—Dugald C. Jackson.

As Chairman of the Committee on Research—Ernest F. Nichols.

The General Secretary presented a report of the letter-ballot on the amendment of By-law (a), Section 1, Article IV, of the Constitution showing a concurring vote of the majority of the entire Council.

The Council approved by letter ballot the granting of a petition for the organization of a chapter covering southern California, with headquarters in Los Angeles, to be known as the Los Angeles Chapter.

Committee Reports

The General Secretary presented the report of the Committee of Tellers which met on May 29, 1923. The Council instructed the General Secretary to give the names of the newly elected officers to the technical press.

NEWS ITEMS

ADOPTION OF THE INDUSTRIAL LIGHTING CODE IN PENNSYLVANIA

According to the May *Bulletin of Information* issued by the Industrial Board, Department of Labor and Industry, Commonwealth of Pennsylvania, the Industrial Lighting Code which has been in the process of revision for a year was adopted by the Industrial Board at its May 10, 1923 meeting.

The revised code is based on the National Lighting Code adopted by the American Engineering Standards Committee as American Standard. The public hearings developed the necessity for changing some of the intensity requirements provided in the National Code, and for providing minimum and recommendatory intensities for a number of industries not covered by the National Code. Rules on Emergency Lighting and Protection against Explosion are also included in the revised draft.

In addition to the general rules, the code contains two tables. Table I is to be used in determining the illumination necessary for industrial establishments. Table II gives the minimum and recommendatory intensities of illumination for various industries and occupations. The following is an abstract of the code as adopted:

"RULE 378. DISTRIBUTION OF LIGHT.

(a) (A-1) Lamps shall be installed in regard to height, spacing, reflectors or other accessories to secure a good distribution of light on the work, avoiding objectionable shadows and excessively sharp contrasts.

"RULE 379. EMERGENCY LIGHTING.

(a) (A-1) All ways or egress of means of escape in establishments wherein persons are employed after darkness shall be provided with a reliable emergency electric lighting circuit, of a type to be approved by the Commissioner of Labor and Industry.

Such emergency lighting shall have a minimum intensity of 0.50 foot-candle on the space.

"RULE 380. INTENSITY OF ILLUMINATION.

"RULE 381. (a) Gas, vapor and dust-proof lighting fixtures shall be provided at all places where explosive gas, vapor, or dust accumulate."

The Industrial Board was assisted by the following persons in the drafting of this code:

Earl A. Anderson, Illuminating Engineering Society, Cleveland; Maurice L. Crass, Grasselli Chemical Co., Cleveland; E. Y. Davidson, Jr., Macbeth-Evans Glass Co., Pittsburgh; H. B. Harmer, Philadelphia Electric Co., Philadelphia; B. E. Hatch, Westinghouse Electric Co., Philadelphia; W. J. Hart, Jones and Laughlin Steel Corp., Pittsburgh; Howard Heslip, Duquesne Light Co., Pittsburgh; Ward Harrison, Illuminating Engineering Society, Cleveland; J. J. Minnick, Westinghouse Electric Co., Philadelphia; W. E. Megraw, H. H. Robertson Co., Pittsburgh; A. A. McLean, Travelers Insurance Co., Pittsburgh; J. W. Pollock, Baldwin Locomotive Works; Miss G. M. Pugh, Consumers' League; Wm. J. Serrill, Illuminating Engineering Society, Philadelphia; Charles Thomas, American Bridge Co., Ambridge, Pa; Walter C. Titus, Jones and Laughlin Steel Co., Pittsburgh.

G. BERTRAM REGAR WINS DOHERTY PRIZE

In 1910 Mr. Henry L. Doherty provided for the annual presentation of a gold medal to the author of the best paper presented before a section of the National Electric Light Association. The prize this year was won by Mr. G. Bertram Regar of the Philadelphia Electric Company, his paper being entitled "More Business through Better Lighting." It is understood that this is the first time that the award of the Doherty prize has been made to the author of a paper dealing with lighting. It will therefore be doubly gratifying to members of this Society to note that this important prize goes to so prominent a member of this Society and that the subject of lighting has thus received such favorable attention at the hands of central station men.

Mr. Regar's distinguished services to the Society include his successful administration of the Committee on Membership during the past two years, during the latter of which he has served also as Chairman of the Lighting Sales Bureau of the National Electric Light Association. Once more attention is thus drawn to the fortunate coincidence of public interest with the interests of the light and power companies in the development of improved illumination. Altruism and commercial interest go hand in hand and many authors like Mr. Regar are promoting the public interest while promoting their private interests through activities directed at the improvement of lighting conditions.

NEW OFFICERS

At the June meeting of the Council the report of the Committee of Tellers was read and accepted. According to the returns reported by the committee the following have been elected to the offices indicated:

General Officers

President, Mr. Clarence L. Law, New York City.

General Secretary, Mr. Samuel G. Hibben, New York City.

Treasurer, Mr. Louis B. Marks, New York City.

Vice-President, Mr. D. McFarlan Moore, Harrison, N. J.

Directors, Messrs. James P. Hanlan, Newark, N. J., Howard Lyon, Gloucester, N. J., and H. F. Wallace, Boston, Mass.

Chicago Section Officers

Chairman, Mr. F. A. Rogers; *Secretary*, Mr. E. J. Teberg; *Board of Managers:* Messrs. A. L. Arenberg, W. S. Hamm, N. B. Hickox, W. E. Quivey and E. D. Tillson.

New England Section Officers

Chairman, Mr. Walter V. Batson; *Secretary*, Mr. Julius Daniels; *Board of Managers:* Messrs. Cyrus Barnes, A. W. Devine, W. S. Fitch, R. W. Hosmer, and J. A. Toohey.

New York Section Officers

Chairman, Mr. L. J. Lewinson; *Secretary*, Mr. J. E. Buckley; *Board of Managers:* Messrs. S. K. Barrett, H. W. Desaix, E. E. Dorting, J. R. Fenniman, and E. H. Hobbie.

Philadelphia Section Officers

Chairman, Mr. H. Calvert; *Secretary*, Mr. J. J. Reilly; *Board of Managers:* Messrs. H. B. Anderson, G. A. Hoadley, M. C. Huse, Howard Lyon, and E. L. Sholl.

NATIONAL ILLUMINATING COMMITTEE OF GREAT BRITAIN*

In the Journal of the Institution of Electrical Engineers, May, 1923, (London), there appears a report of the Chairman of the year 1922, and in view of its interest to members of the I. E. S., is reprinted below.

In February last (1922) the provisional Definitions of Photometric Terms and Units proposed by the British National Committee were published together with a prefatory note and have been officially adopted by the three constituent Societies. They also form the basis of a set of Photometric Definitions shortly to be issued by the British Engineering Standards Association as part of a comprehensive set of Electrical Engineering terms.

The Definitions in question, whilst agreeing with the decisions of the International Commission on Illumination held in Paris in 1921, go considerably further and are in some respects at variance with a set of Definitions approved in July, 1922, by the American Engineering Standards Committee.[1] The occasion of a visit by Dr. Clayton H. Sharp to this country in December last was seized upon to discuss these Definitions with one so largely instrumental in the drafting of the American Definitions. Dr. Sharp kindly consented to attend a Meeting of the Nomenclature Sub-Committee, and as a result of this interchange of views, the Sub-Committee are now considering how the proposed Definitions can be amended so as to minimize the points of difference between this country and the United States.

A preliminary list of Symbols has also been prepared by the Nomenclature Sub-Committee and, after submission to the British Committee, these have been communicated to a number of interested Societies, publication being deferred until their criticisms, if any, have been considered.

Dr. C. O. Mailloux (U.S.A.) and Mr. K. Edgcumbe (Gt. Britain) were asked by the central office of the National Illumination Commission to prepare an English translation of the French official text of Terms and Definitions adopted in Paris in 1921. A meeting was held in this country and the translation agreed upon. The text forms an Appendix to this Report.

At the 1921 Paris Meeting of the Commission an International Committee on Automobile Headlights was appointed and Mr. K. Edgcumbe was subsequently nominated by the British National Committee as their Representative thereon. A fairly complete set of recommendations having been drawn up in the United States by a Committee under the Chairmanship of Dr. Clayton H. Sharp, the subject was discussed with that gentleman on the occasion of his visit to this country, and at a subsequent interview with Mr. Perrin of the Ministry of Transport the question was raised of how the British National Committee could best serve the interests of this country in connection with Automobile Headlights. It appeared that the most useful course would be to appoint a Sub-Committee to consider the recommendations which had already been published in other countries, with a view, if possible, of arriving at common agreement through the medium of the International Headlights Committee.

*See *Institution Notes*, No. 30, page 11, January 1922.

[1]Illuminating Engineering Nomenclature and Photometric Standards, American Standard, approved July 11, 1922 by A. E. S. C.

In view of the fact that a large and increasing part of the work of the British National Committee relates to standardization, it was decided, with the approval of the three constituent Societies to ask the British Engineering Standards Association to form a sectional Committee on Illumination to which such matters could be referred. It is proposed that this Committee should deal solely with standardization or similar questions referred to it by the British National Committee, all international matters being dealt with by the National Committee as heretofore.

K. Edgcumbe.
January, 1923. *Chairman.*

PHOTOMETRIC DEFINITIONS

Official Translation of the French Text

Luminous flux.—Is the rate of passage of radiant energy evaluated by reference to the luminous sensation produced by it.

Although luminous flux should be regarded, strictly, as the rate of passage of radiant energy as just defined, it can, nevertheless, be accepted as an entity for the purposes of practical photometry, since the velocity may be regarded as being constant under those conditions.

The unit of luminous flux is the lumen.—It is equal to the flux emitted in unit solid angle by a uniform point source of one international candle.

Illumination.—The illumination at a point of a surface is the density of the luminous flux at that point, or the quotient of the flux by the area of the surface when the latter is uniformly illuminated.

The practical unit of illumination is the lux.—It is the illumination of a surface one square metre in area, receiving a uniformly distributed flux of one lumen, or the illumination produced at the surface of a sphere having a radius of one metre by a uniform point source of one international candle situated at its centre.

In view of certain recognized usages, illumination may also be expressed in terms of the following units:—

Taking the centimetre as the unit of length, the unit of illumination is the lumen per square centimetre; it is known as the "phot." Taking the foot as the unit of length, the unit of illumination is the lumen per square foot; it is known as the "foot-candle."

1 foot-candle = 10.764 lux
= 1.0764 milli-phot

Luminous intensity (candlepower).—The luminous intensity (candlepower) of a point source in any direction is the luminous flux per unit solid angle emitted by that source in that direction. (The flux emanating from a source whose dimensions are negligible in comparison with the distance from which it is observed may be considered as coming from a point.)

The unit of luminous intensity (candlepower) is the International Candle, such as resulted from agreements effected between the three National Standardizing Laboratories of France, Great Britain and the United States in 1909.*

This unit has been maintained since then by means of incandescent electric lamps in these laboratories which continue to be entrusted with its maintenance.

*These Laboratories are: the Laboratorie Central d'Electricité in Paris; the National Physical Laboratory in Teddington, and the Bureau of Standards in Washington.

SUPPORT THE MEMBERSHIP DRIVE

The membership drive under the direction of Vice-President G. Bertram Regar of Philadelphia is proving fruitful of splendid results. A record of newly elected members of nearly two hundred and fifty is reported to date which is very gratifying to the officers and members of the I. E. S.

The drive will be earnestly continued for the next three months and the committee hopes to receive at least one hundred new applications during this period. To achieve this goal means the hearty cooperation and loyal support of *each individual member.*

The Constitution provides that membership dues shall date from the quarter of the fiscal year nearest the date of notice of admission to the applicant. For the last three months of the fiscal year the dues for the grade of *associate member* amount to $1.88 and for the grade of *member* $3.75; the entrance fee is $2.50.

Application blanks and membership literature can be secured from members of the committee or from the General Office.

Have *you* sent in a signed application? Have *you* sent to the chairman, Mr. G. Bertram Regar, 1000 Chestnut Street, Philadelphia, names of *prospective applicants?* Show your loyalty and interest in the membership drive by securing a new member.

I. E. S. CONVENTION AT LAKE GEORGE

The 1923 Convention of the Illuminating Engineering Society is to be held September 24 to 28 inclusive at Lake George, N. Y., famous the world over as the most picturesque resort in America. The lake is 32 miles in length, its width varies from three quarters of a mile to four miles, dotted with many islands and surrounded by majestic mountains. The headquarters of the Convention will be the Fort William Henry Hotel, possessing every modern convenience and attraction. Golf, tennis, boating and bathing are splendidly provided for.

Lake George is seventy miles from Albany, accessible by railroad and unexcelled automobile highways. A wealth of historical interest including old forts and battlegrounds prevails in the immediate vicinity.

A unique program of entertainment is being provided and unusual spectacular lighting features are being planned. It is hoped to combine business and pleasure at this Convention in a manner to enable all visiting delegates and particularly the ladies to enjoy the wealth of scenic beauty so abundant in this wonderful country of mountains and lakes.

A well balanced program of Commercial and Technical papers is being prepared by the Committee on papers under the direction of Mr. J. L. Stair of Chicago.

COMMITTEE ACTIVITIES

The General Convention Committee held its first meeting at the Society Headquarters on June 7, 1923. The general program of entertainment and other features of the convention was outlined by Chairman Ryan and a tentative schedule of events was adopted.

Convention Headquarters at Fort William Henry Hotel, Lake George, N. Y.

The Boat Landing.

View of Boat Landing from hotel.

Lake George, N. Y.

At the meeting of the Sectional Committee of the A. E. S. C. on June 4, 1923 the following officers were elected: Mr. L. B. Marks, Chairman; Mr. Sullivan W. Jones, Vice-Chairman; and Mr. W. F. Little, Secretary. This sectional committee is considering the revision of the Code of School Lighting.

A joint session of the Committee on Lighting Legislation and the Sectional Committee of the A.E.S.C. convened on June 4, 1923 at which time the discussion of the revised Code of School Lighting was held. The revised Code will be presented at the coming convention in September for general discussion by members of the I. E. S.

The Committee on Nomenclature and Standards met at the Society Headquarters on June 22, 1923 to consider the report to be presented at the convention and a summary of the changes in the American Standard which have so far been agreed to in previous meetings of the committee.

OBITUARY

Prof. Arthur Gordon Webster of Clark University, an eminent physicist, died from self-inflicted bullet wound on May 15, 1923. This tragic occurrence, which means a great loss to science caused amazement among Professor Webster's friends and associates, for he had shown no signs of depression and must, it is believed, have taken his life as the result of a sudden impulse. He had attained great success in many scientific lines and was recognized as one of the world's greatest authorities on electricity and sound. He was born in Brookline, Mass., was graduated from Harvard in 1885 and later studied in Paris, Berlin and Stockholm. After spending a year as instructor at Harvard, he entered the service of Clark University, where he was successively docent in physics, assistant professor of physics, professor of physics and director of the physical laboratory, holding the last-named offices at the time of his death. Professor Webster was the author of several important works on electricity and dynamics and during the war was made a member of the Naval Advisory Board of Scientists, of which Thomas A. Edison was chairman. All who knew him will mourn the loss of a steadfast friend and a delightful personality, and the electrical industry will sadly miss the fruits of his brain and the enthusiasm he inspired for scientific research.

Mr. Uhl M. Smith, of the Bureau of Standards, Washington, D. C., was instantly killed on April 21, 1923, when a Martin air service bombing plane nose-dived into the Great Miami river at Dayton, Ohio.

Mr. Smith was at Dayton in connection with some work on Colors for Traffic Signals in which he had taken a leading part. At the Bureau he was in charge of work on automobile lighting in general, and was a member of the I. E. S. Committee on Motor Vehicle Lighting.

BIOGRAPHY OF CLARENCE L. LAW

PRESIDENT-ELECT I. E. S.

1923-1924

Mr. Clarence L. Law, newly-elected President of the Illuminating Engineering Society, was born in New York City, April 15, 1885. His education was received in New York City elementary and high schools, supplemented by private tutors.

Mr. Law became connected with the electrical industry November 1, 1906, when he entered the employ of The New York Edison Company as a special inspector. A year later he was made Special Agent; in July, 1910, he was advanced to Manager of the Bureau of Illuminating Engineering, and was recently appointed Assistant to the General Commercial Manager, which position he now holds.

During Mr. Law's period of service with The New York Edison Company, he specialized in the field of illumination from the time when it became necessary to demonstrate the most economical and efficient use of light by means of improved and perfected lamps. Mr. Law's duties, during his association with The New York Edison Company, covered work pertinent to illuminating engineering, large building oversight, surveys, lamp development, special outdoor decorative and spectacular lighting.

Mr. Law is affiliated with a number of prominent organizations, including several contributing to the development of the electrical industry. He is at present Chairman of the Board of Trustees of the Association of Employees of The New York Edison Company; Director, New York State Commission for the Prevention of Blindness; Member, American Association for the Advancement of Science; the Architectural League of New York; the New York Electrical League; the American Institute of Electrical Engineers; a former member of the Executive Committee of the Commercial Section of the National Electric Light Association. Mr. Law has also served on a number of Committees of the N. E. L. A., and is Past-Chairman of the Metropolitan New York Section.

Mr. Law joined the Illuminating Engineering Society in 1912, and has served in the capacity of Secretary of the New York Section; Acting Chairman, New York Section; Vice-President, for two years; General Secretary, for five years; and Director for one year, and is also a member of several committees. He has presented papers before the Society on different subjects pertaining to illuminating engineering.

In local movements, in New York City, Mr. Law is active in welfare work, and is connected with civic organizations such as The Merchants' Association, the Fifth Avenue Association and the Broadway Association.

Clarence L. Law
President-elect I. E. S.
1923-1924

PERSONAL MENTION

Mr. F. M. Feiker, formerly vice-president of the McGraw-Hill Company, Inc., and more recently on leave of absence as special agent of the Department of Commerce at Washington will after his return from Washington, be associated with the staff of the Society for Electrical Development, New York City. As a result of the appointment of Mr. Feiker the various branches of the electrical industry served by the society will secure the benefit of his broad experience and background, for he will be available to act as a special counselor to engineers, manufacturers, central stations, jobbers, contractor-dealers and publishers. His special training and wide knowledge in the engineering publishing and public relations field of many industries, qualify him eminently for such consulting work. Mr. Feiker will retain a consulting relation to the McGraw-Hill Company, and he will continue in a similar capacity his relation to the problems of personnel and organization of the Department of Commerce at Washington.

Dr. A. S. McAllister, engineer physicist, Bureau of Standards, who during the past two years has been liaison officer of the U. S. Bureau of Standards and the Federal Specifications Board assigned to the headquarters of the American Engineering Standards Committee at New York City, has been recalled to Washington for special work, by Secretary Hoover of the Department of Commerce. Dr. D. R. Harper 3d, physicist of the Bureau of Standards, has been assigned to the American Engineering Standards Committee succeeding Dr. McAllister.

Mr. W. E. Clement, commercial agent of the New Orleans Public Service Co., was recently elected president of the Electrical League of New Orleans.

Mr. Walter H. Johnson, senior vice-president of the Philadelphia Electric Co., was elected president of the National Electric Light Association at the recent convention held in New York City.

Mr. Dudley Farrand, assistant to the president of the Public Service Corporation of New Jersey, was recently elected vice-president in charge of industrial relations.

Mr. Edwin F. Guth is president of the Edwin F. Guth Company, a new organization of the united interests of the St. Louis Brass Mfg. Co. and the Brascolite Co., recently formed in St. Louis, Mo.

Prof. Harris J. Ryan of Stanford University, California, was elected president of the American Institute of Electrical Engineers at its annual business meeting, held in New York last May.

Mr. J. R. Fenniman has recently been elected assistant treasurer of the Consolidated Gas Co. of New York City.

Mr. Franklin S. Terry, chairman of the advisory board of the National Lamp Works, Nela Park, Cleveland was elected vice-president of the General Electric Company at a meeting of the board of directors held in New York City on June 22. 1923.

Mr. B. G. Tremaine, vice-chairman of the advisory board of the National Lamp Works, Nela Park, Cleveland was elected director of the General Electric Company on June 22, 1923.

Mr. Samuel G. Hibben addressed the Canadian Electrical Association at their convention in Montreal on June 22, 1923 upon the subject of the industrial lighting codes and the reasons for their adoption by the various states.

Mr. D. W. Atwater presented an industrial lighting lecture, explaining the Pennsylvania legislation, at Ridgway, Pa., before the industrial plant engineers of that territory.

GENERAL OFFICE NOTES

The Code of Lighting Factories Mills and Other Work Places has been reprinted as Bulletin No. 331, U. S. Department of Labor, Bureau of Labor Statistics. Copies of this bulletin can be obtained from Mr. Ethelbert Stewart, U. S. Commissioner of Labor Statistics, Washington, D. C.

A request to publish the Code of Lighting, Factories Mills and Other Work Places has been granted M. Remy Delauney, Editor in Chief of the Bulletin of Labor Inspection, Paris, France. It is very gratifying to learn that a translation of the I. E. S. Code will appear in an early issue of the bulletin.

TRANSACTIONS for October, November and December, 1922, and January, 1923, are out of print. Please advise the General Secretary of any of these issues for sale and price will be quoted.

WALSH PAPER DISCUSSIONS

Through an inadvertence a paper entitled "Note on the Integrating Sphere Reflectometer" by John W. T. Walsh, was printed in the Abstracts Section of the May number without an explanatory note.

This paper is being presented to the membership under the auspices of the Sub-committee on Reflection Factor Measurements, and this committee invites written discussion of the paper which will be presented to Mr. Walsh when received, and the paper and discussions with Mr. Walsh's rejoinder will be brought before the convention at Lake George in September.

Discussions should be sent to Dr. Clayton H. Sharp, Chairman, 80th Street and East End Avenue, New York City.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illumi-
ing engineering and allied subjects. This index is arranged alphabetically according
the names of the reference publications. The references are then given in order of
date of publication. Important references not appearing herein should be called
the attention of the Illuminating Engineering Society, 29 W. 39th St., New York,
Y.

	AUTHOR	DATE	PAGE
erican Journal of Physiology			
Visual Perception and the Retinal Mosaic —I. Retinal Mean Local Sign—an Explanation of the Fineness of Binocular Perception of Distance.	E. E. Anderson and F. W. Weymouth	May	561
erican Gas Association—Bulletin of Abstracts			
Control of Industrial Processes by Light Sensitive Means.		May	345
Action of Light on Paint Pigments Etc.		May	369
rophysical Journal			
On Visual & Photographic Albedo of the Earth.	K. R. Ramanathan	Apr.	177
ıtral Station			
Electric Lighting Today.		May	346
emical Abstracts			
Notes on the Influence of Colored and Ultra-Violet Light on the Drying time of Linseed Oil and Varnish.	H. A. Gardner and H. C. Parks	May	1894
e Electrician			
Light Without Heat		Apr.	465
The Lighting of Printing Works		May	474
Electric Miners' Lamps		May	498
ctrical Review			
Daylight Illumination		Apr.	603
Factory Lighting		Apr.	647
Electric Lamps in Mines		Apr.	662
The Lighting of Printing Works		May	682
Electric Lighting of Trains		May	683
The Illumination of the "Coliseum" Tower		May	746
ctrical Times			
When Is Light Not Light?	Blyth Lawrence	Apr.	418

Electrical World		
Non-Fading Light Needed to Preserve Colors		May
Increased Coal Output By Better Mine Lighting		May
Will Consider Illuminating Engineering Nomenclature		May
Silk-Mill Lighting		May
Modified Ventilators for Street Lamps	S. G. Hunter	May
Syracuse's Lighting Plan		May
Elektrotechnische Zeitschrift		
Eine Wechselstrom—Projektion Lampe mit erhohter Lichtausbeute	B. Schäfer	Apr.
Lampenblockierung		Apr.
Gas Journal		
The Lighting of Printing Works		May
Gas und Wasserfach		
Gasbeleuchtung und Propaganda		Mar.
Illuminating Engineer		
Street Lighting Requirements	H. T. Harrison	Jan.
Street Lighting & Safety	L. Gaster	Jan.
Public Lighting by Gas		Jan.
Changes in Gas Lighting in Germany		Jan.
Lighting Conditions in Mines (Effect on Output)		Jan.
The Theory of Vision	F. W. Edridge-Green	Jan.
Industrial & Engineering Chemistry		
The Influence of Light on Inorganic Matter and Life Processes	Oscar Baudisch	May
Journal of Electricity & Western Industry		
Plan Better Lighting in Schools to Save Eyes of Youth		May
Journal of Experimental Psychology		
Accommodation & Convergence Under Low Illumination	Harold E. Israel	June
Journal of Optical Society		
A Chart of the Flicker Photometer	H. E. Ives	May
The Design of Large Incandescent Lamps	P. G. Nutting	May
Journal of Physical Chemistry		
Structural Colors in Feathers II	C. W. Mason	May
Licht und Lampe		
Die Bewerting des Lichtes Elektrischer Gluhlampen	A. R. Meyer	Apr.
Die Beleuchtungs Glasindustrie und der Modern Gewordene Agyptische Formenstil	Max Beckert	Apr.

Leitsatze für Beleuchtung im Freien	H. Lux	Apr.	207
ghting Fixtures & Lighting			
Superb Lighting in Keith's $5,00c,000 Cleveland Theatre		May	13
onthly Abstract Bulletin-Eastman Kodak Co.			
New Method of Measuring Colors	I. Ginsberg	Apr.	120
ture			
Colour Temperature & Brightness of Moonlight	W. E. Forsythe	Apr.	533
tional Research Council Bulletin			
Selected Topics in the Field of Luminescence		Mar.	
ture			
Sunlight & Disease	C. W. Saleeby	Apr.	574
Phosphorescence Caused by Active Nitrogen	E. P. Lewes	May	599
ger's Archiv f. d. g. Physiologie			
Untersuchugen über Die Wirkung der Ultravioletten Strahlen Auf Eiwszlosungen	Rudolph Mond	Nov.	540
ysiological Abstracts		1922	
The Absorption of Ultra-Violet Rays by Living Tissue, Spectacle Glass, and Some Physiological Solutions	L. C. J. Mitchell	Apr.	72
Studies in Photosynthesis in Marine Algae	B. Moore W. Whitley T. A. Webster	Apr.	72
The Action of Artificial Sunlight on Metabolism	W. Lasch	Apr.	73
ysikalische Berichte			
De l'Influence de la Temperature sur la Transparence aux Rayons-Violets de Differentes Especes de Verres	W. Reider	Apr.	424
Fortschritte in Strahlungsmessungen	C. Dorno	Apr.	424
ceedings of the Royal Society "A"			
Studies of Iridescent Colour, and the Structure Producing It	Lord Rayleigh	May	233
ceedings of the Royal Society "B"			
The Pigmentary Effect or System III Colour Response in the Hypophysectomized Frog	L. T. Hogben F. R. Winton	May	15
rue General de L'Electricite			
Comite National Francais de l'Eclairage		May	769
Etude sur les Projecteurs		Apr.	129D

Lampe Polygonale Destine a Donner un Eclairage sans Ombre	D. Polack	Apr.	13
Loupe Eclairante	P. Seve	Apr.	13
L'Eclairage Exterieur Des Automobiles	L. Bruninghaus	Apr.	
Scientific American			
The Aerial Lighthouse		June	
Science Abstracts "A"			
Measurement of Visual Acquity	A. Contino	Apr.	
Science			
Standardization of Traffic Signal Colors		May	
Zeitschrift fur Physik			
Zur Frage Nach der Proportionalität zwischen Lichtstarke und Photostrom bie Edslgasgefulten Alkaleinetallzellen	H. V. Halban L. Ebert	Mar.	
Zeitschrift fur Instrumenkunde			
Die Photometric Optischer Instrumente	J. V. Guild	Apr.	
Ein Spektrophotometer ohne Polarisation	A. J. V. Bull	Apr.	

OFFICERS & COUNCIL

1922-23

President

Ward Harrison,
Nela Park,
Cleveland, Oho
Term expires Sept. 30, 1923

Junior Past-Presidents

Geo. H. Harries
208 South LaSalle Street,
Chicago, Ill.
Term expires Sept 30, 1923

Geo. S. Crampton,
1819 Walnut Street,
Piladelphia, Pa.
Term expires Sept. 30, 1924

Vice-Presidents

F. M. Feiker,
36th Street and 10th Avenue,
New York, N. Y.
Term expires Sept. 30, 1923

O. L. Johnson,
230 South Clark Street
Chicago, Ill.
Term expires Sept. 30, 1924

Wm. J. Drisko,
Mass. Inst. of Technology,
Cambridge, Mass.
Term expires Sept. 30, 1924

G. Bertram Regar,
1000 Chestnut Street,
Philadelphia, Pa.
Term expires Sept. 30, 1924

General Secretary

Samuel G. Hibben,
165 Broadway,
New York, N. Y.
Term expires Sept. 30, 1923

Treasurer

L. B. Marks,
103 Park Avenue,
New York, N. Y.
Term expires Sept. 30, 1923

Directors

Terms expire Sept. 30, 1923

Walton Forstall,
1401 Arch Street,
Philadelphia, Pa.

Adolph Hertz,
Irving Place and 15th Street,
New York, N. Y.

Frank S. Price,
160 Pearl Street,
Boston, Mass.

Terms expire Sept. 30, 1924

F. C. Caldwell,
Ohio State University,
Columbus, Ohio

Augustus D. Curtis,
235 W. Jackson Blvd.
Chicago, Ill.

Preston S. Millar,
80th St. and East End Ave.,
New York, N. Y.

Terms expire Sept. 30, 1925

Frank R. Barnitz,
130 East 15th St.,
New York, N. Y.

Clarence L. Law,
Irving Place and 15th Street,
New York, N. Y.

A. L. Powell,
Fifth and Sussex Sts.
Harrison, N. J.

SECTION & CHAPTER OFFICERS

Chicago Section

CHAIRMAN..........................Albert L. Arenberg, 316 S. Wells St., Chicago, Ill.
SECRETARY....F. A. Rogers, Lewis Institute, Madison and Robey Sts., Chicago, Ill.

MANAGERS

J. H. Allen..................................Monadnock Block, Chicago, Ill.
F. A. DeLay..................................72 W. Adams St., Chicago, Ill.
F. Lee Farmer..............................216 S. Jefferson St., Chicago, Ill.
W. M. Goodrich ....500 S. Clinton St., Chicago. Ill.
J. J. Kirk.....................................72 W. Adams St., Chicago, Ill.

New England Section

CHAIRMAN..............................R. R. Burnham, 119 Water St., Boston, Mass.
SECRETARY..............................J. Daniels, 39 Boylston Street, Boston, Mass.

MANAGERS

W. V. Batson...............................210 South Street, Boston, Mass.
Francis A. Gallagher.................814 Turks Head Bldg., Providence, R. I.
J. A. Toohey....................................Box 3396, Boston, Mass.
L. T. Troland............................Harvard Univ., Cambridge, Mass.
J. L. Tudbury...............................247 Essex Street, Salem, Mass.

New York Section

CHAIRMAN.........................A. L. Powell, Edison Lamp Works, Harrison, N. J.
SECRETARY..................J. E. Buckley, Irving Place and 15th St., New York, N. Y.

MANAGERS

R. B. Burton...........................6 W. 48th Street, New York, N. Y.
J. R. Fenniman........................130 E. 15th Street, New York, N. Y.
A. M. Perry...................10th Ave. and 36th Street, New York, N. Y.
H. A. Sinclair..........................526 W. 34th Street, New York, N. Y.
Geo. Strahan...........................507 W. 24th Street, New York, N. Y.

Philadelphia Section

CHAIRMAN.............................Howard Lyon, Welsbach Co., Gloucester, N. J.
SECRETARY..........................H. Calvert, 2114 Sansom Street, Philadelphia, Pa.

MANAGERS

H. B. Andersen.......................20 Maplewood Ave., Philadelphia, Pa.
C. E. Clewell..............................Univ. of Penn., Philadelphia, Pa.
M. C. Huse.........................1000 Chestnut Street, Philadelphia, Pa.
J. B. Kelley ....235 Market Street, Philadelphia, Pa.
W. E. Saunders.......................Broad and Arch Sts., Philadelphia, Pa.

Cleveland Chapter

CHAIRMAN....................................C. L. Dows, Nela Park, Cleveland, Ohio
SECRETARY..............................E. W. Commery, Nela Park, Cleveland, Ohio

San Francisco Bay Cities Chapter

CHAIRMAN......................Leonard F. Voyer, Rialto Bldg., San Francisco, Calif.
TREASURER..........................J. A. Vandegrift, 1648 16th Street, Oakland, Calif.

Toronto Chapter

CHAIRMAN........................G. R. Anderson, Univ. of Toronto, Toronto, Canada
SECRETARY-TREASURER...........M. B. Hastings, 62 Front St. W., Toronto, Canada

Northern New Jersey Chapter

CHAIRMAN.............................W. T. Blackwell, 80 Park Place, Newark, N. J.
SECRETARY .... H. C. Calahan, 52 Lafayette St., Newark, N. J.
TREASURER..........................George E. Davis, 15 Central Ave., Newark, N. J.

Columbus Chapter

CHAIRMAN.......................G. F. Evans, 162 West Long Street, Columbus, Ohio
SECRETARY.....................R. C. Moore, 146 North Third Street, Columbus, Ohio

Michigan Chapter

CHAIRMAN......................... James M. Ketch, 2000 Second Ave., Detroit, Mich.
SECRETARY-TREASURER................A. L. Lent, 2000 Second Ave., Detroit, Mich.

CALIFORNIA:	San Francisco...	Romaine W. Myers, 204 Bacon Building, Oakland.
	Los Angeles....	F. S. Mills, 631 Pacific Finance Building.
COLORADO:	Denver........	G. O. Hodgson, Edison Lamp Works.
CONNECTICUT:	New Haven....	Charles F. Scott, Yale University J. Arnold Norcross, 80 Crown Street.
	Hartford.......	R. E. Simpson, Travelers Insurance Co.
DISTRICT OF COLUMBIA:	Washington....	R. B. Patterson, 213 14th Street. E. C. Crittenden Bureau of Standards.
GEORGIA:	Atlanta........	Charles A. Collier, Electric and Gas Building.
IDAHO:	Boise..........	W. R. Putnam, Idaho Power Co.
KENTUCKY:	Louisville......	H. B. Heyburn, Second and Washington Sts.
LOUISIANA:	New Orleans...	Douglas Anderson, Tulane University of Louisiana.
MASSACHUSETTS:	Springfield.....	J. F. Murray, United Electric Light Co.
	Worcester......	Carl D. Knight, Worcester Polytechnic Institute.
MICHIGAN:	Detroit........	F. R. Mistersky, 129 Kenilworth Avenue. Charles C. Monroe, Detroit Edison Co.
MINNESOTA:	St. Paul.......	A. L. Abbott, 174 E. 6th Street.
	Minneapolis....	G. D. Shepardson, University of Minnesota.
MISSOURI:	St. Louis......	Louis D. Moore, 1130 Railway Exchange Bldg.
NEW YORK:	Rochester......	Frank C. Taylor, 166 Shepard St.
	Schenectady...	S. H. Blake, General Electric Co.
OHIO:	Cincinnati.....	A. M. Wilson, University of Cincinnati.
	Columbus......	F. C. Caldwell, Ohio State University.
	Toledo........	W. E. Richards, Toledo Railway and Light Co.
OREGON:	Portland.......	F. H. Murphy, Portland Railway Light and Power Co. Electric Building.
PENNSYLVANIA:	Pittsburgh.....	L. O. Grondahl, Union Switch and Signal Co., Swissvale, Pa.
RHODE ISLAND:	Providence.....	F. A. Gallagher Narragansett Elec. Lighting Co.
TEXAS:	Austin.........	J. M. Bryant, University of Texas.
UTAH:	Salt Lake City.	R. H. Ashworth, Kearns Bldg.
VIRGINIA:	Charlottesville	W. S. Rodman, University of Virginia.
WASHINGTON:	Seattle........	Fred A. Osborn, University of Washington.
WISCONSIN:	Milwaukee.....	F. A. Vaughn, Metropolitan Block, Third and State Sts.
CANADA:	Montreal......	L. V. Webber, 285 Beaver Hall Hill.
SOUTH AFRICA:	Johannesburg..	H. A. Tinson, South African Gen. Elec. Co. Southern Life Buildings, Transvaal.

OFFICIAL REPRESENTATIVES TO OTHER ORGANIZATIONS

On the United States National Committee of the International Commission on Illumination..........	L. B. Marks Preston S. Millar
On American Institute of Electrical Engineers Standards Committee....	Clayton H. Sharp
On Governing Board of the American Association for the Advancement of Science..........	Ernest F. Nichols Clayton H. Sharp
On the Advisory Committee, Engineering Division, National Research Council..........	Dugald C. Jackson
On the Fixture Manufacturers Committee to prepare a Code of Luminaire Design..........	E. W. Commery J. W. Gosling S. G. Hibben M. Luckiesh R. H. Maurer A. L. Powell Samuel Snyder
On A. E. S. C. Sectional Committee, Building Exits Code..........	R. E. Simpson

COMMITTEES

1922-1923

Except as noted below, all committees are appointed by the President, subject to the approval of the Council, and terminate at the time of the first Council meeting of each new administration, in the month of October. The duties of each committee are indicated.

WARD HARRISON, President, Ex-officio member of all Committees

(1) STANDING COMMITTEES AUTHORIZED BY THE CONSTITUTION AND BY-LAWS

COUNCIL EXECUTIVE—(*Consisting of the President, General Secretary, Treasurer and two members of the Council.) Act for the Council between sessions of the latter.*

Ward Harrison, Chariman.
Nela Park, Cleveland, Ohio.
Walton Forstall, Clarence L. Law,
Samuel G. Hibben, L. B. Marks.

FINANCE.—(*Of three members: to continue until successor is appointed.) Prepare a budget; approve expenditures; manage the finances; and keep the Council informed on the financial condition.*

Adolph Hertz, Chairman.
Irving Place & 15th St., New York, N. Y.
Walton Forstall, D. McFarlan Moore.

PAPERS.—(*Of at least five members.) Provide the program for the annual convention; pass on papers and communications for publication; and provide papers and speakers for joint sessions with other societies.*

J. L. Stair, Chairman.
235 W. Jackson Blvd., Chicago, Ill.
A. L. Powell, Vice-Chairman.
Fifth and Sussex Sts., Harrison, N. J.

E. A. Anderson, Norman D. Macdonald,
Geo. G. Cousins, F. H. Murphy,
H. H. Higbie, J. J. Ryan,
Howard Lyon, Albert Scheible.

Chairman of Section and Chapter Papers Committees, Ex-officio Members.

EDITING AND PUBLICATION.—(*Of three members.) Edit papers and discussions; and publish the Transactions.*

Norman D. Macdonald, Chairman.
80th St. and E. End Ave., New York, N. Y.
Allen M. Perry, Ralph C. Rodgers.

GENERAL BOARD OF EXAMINERS.—(*Appointed by the President.) Pass upon the eligibility of applicants for membership or for changes in grade of membership.*

Norman Macbeth, Chairman.
227 W. 17th St., New York, N. Y.
Clarence L. Law, L. J. Lewinson.

(2) COMMITTEES THAT ARE CUSTOMARILY CONTINUED FROM YEAR TO YEAR.

LIGHTING LEGISLATION.—*Prepare a digest of laws on Illumination; cooperate with other bodies in promoting wise legislation on illumination; and prepare codes of lighting in certain special fields. To function also as a Technical Committee on Industrial Lighting.*

L. B. Marks, Chairman.
103 Park Avenue, New York, N. Y.
W. F. Little, Secretary.
80th St. and E. End Ave., New York, N. Y.

W. T. Blackwell, J. A. Hoeveler,
F. C. Caldwell, Clarence L. Law,
C. E. Clewell, M. G. Llyod,
Geo. S. Crampton, M. Luckiesh,
H. B. Dates, R. H. Maurer,
E. Y. Davidson, Jr., A. S. McAllister,
W. A. D. Evans, W. J. Serrill,
S. G. Hibben, R. E. Simpson,
G. H. Stickney.

MEMBERSHIP.—*To obtain additional individual memberships.*

G. Bertram Regar, Chairman.
1000 Chestnut St., Philadelphia, Pa.,
J. F. Anderson, F. W. Bliss,
A. L. Arenberg, R. I. Brown,
C. A. Atherton, H. M. Camp,
W. T. Blackwell, W. E. Clement,

George G. Cousins, Merritt C. Huse,
Terrell Croft, L. B. Johnson,
J. Daniels, C. C. Munroe,
E. Y. Davidson, Jr., F. H. Murphy,
Robert B. Ely, H. G. Smith,
R. W. Everson, H. H. Smith,
H. W. Fuller, E. W. Spitz,
H. E. Hobson, Clare N. Stannard,
J. A. Hoeveler, O. R. Toman,
L. A. S. Wood.

MOTOR VEHICLE LIGHTING.

C. H. Sharp, Chairman.
80th St. and E. End Ave., New York, N. Y.

G. H. Stickney, Vice-Chairman.
Fifth and Sussex St., Harrison, N. J.

F. C. Caldwell, W. F. Little,
A. W. Devine, W. A. McKay,
C. E. Godley, A. L. McMurtry,
C. A. B. Halvorson, H. H. Magdsick,
J. A. Hoeveler, L. C. Porter,
L. E. Voyer, Representative in State of Cal.

NOMENCLATURE AND STANDARDS—*Define the terms and standards of Illumination; and endeavor to obtain uniformity in nomenclature.*

E. C. Crittenden, Chairman.
Bureau of Standards, Washington, D. C.

Howard Lyon, Secretary.
Welsbach Co., Gloucester, N. J.

G. A. Hoadley, A. S. McAllister,
E. P. Hyde, E. C. McKinnie,*
A. E. Kennelly, C. H. Sharp,
M. Luckiesh, W. J. Serrill,
C. O. Mailloux, G. H. Stickney.

PROGRESS.—*Submit to the annual convention a report on the progress of the year in the science and art of Illumination.*

F. E. Cady, Chairman.
Nela Park, Cleveland, O.

G. S. Crampton, W. E. Saunders.

RESEARCH.—*Stimulate research in the field of illumination; and keep informed of the progress of research.*

E. F. Nichols, Chairman.
Nela Park, Cleveland, O.

W. T. Bovie,* Thomas Scofield,*
Alex. Duane, C. H. Sharp,
Knight Dunlap, C. A. Skinner,*
E. N. Harvey,* L. T. Troland,
M. Luckiesh, F. H. Verhoeff.*

(3) TEMPORARY COMMITTEES FOR SPECIAL PURPOSES.

SKY BRIGHTNESS.

H. H. Kimball, Chairman.
U. S. Weather Bureau, Washington, D. C.

E. C. Crittenden, W. F. Little,
E. H. Hobbie, M. Luckiesh,
Bassett Jones, L. B. Marks.
I. G. Priest.*

COMMITTEE TO COOPERATE WITH FIXTURE MANUFACTURERS

To Prepare Code of Luminaire Design

M. Luckiesh, Chairman,
Nela Park, Cleveland, O.
E. W. Commery, Secretary,
Nela Park, Cleveland, O.

S. G. Hibben, R. H. Maurer,
J. W. Gosling,* A. L. Powell,
Samuel Snyder.

COMMITTEE ON NEW SECTIONS AND CHAPTERS

D. McFarlan Moore, Chairman.
Edison Lamp Works, Harrison, N. J.

COMMITTEE TO PREPARE A BULLETIN ON RESIDENCE LIGHTING BY GAS

Howard Lyon, R. H. Maurer.

COMMITTEE TO PREPARE A BULLETIN ON RESIDENCE LIGHTING BY ELECTRICITY

Samuel G. Hibben, Chairman.
165 Broadway, New York, N. Y.

Geo. Ainsworth, M. Luckiesh,
F. E. Cady, W. R. M'Coy,
O. H. Caldwell, Herman Plaut,
W. J. Drisko, A. L. Powell,
R. B. Ely, F. B. Rae, Jr.,*
Gertrude R. Ferree,* R. C. Rodgers,
R. S. Hale, J. W. Smith,*
F. Y. Joannes,* J. L. Stair,
Clarence L. Law, E. D. Tillson,
D. H. Tuck.

GENERAL CONVENTION COMMITTEE

W. D' A. Ryan, Chairman.
General Electric Co., Schenectady, N. Y.

H. W. Peck, Vice-Chairman.*
Adirondack Power & Light Corp., Schenectady, N. Y.

H. E. Mahan, Secretary.
General Electric Co., Schenectady, N. Y.

Alexander Anderson,* G. Bertram Regar,
B. S. Beach,* W. L. Robb,
N. R. Birge, W. M. Skiff,
W. T. Blackwell, J. L. Stair,
S. H. Blake, C. P. Steinmetz,
H. Calvert, G. H. Stickney,
A. D. Cameron,* D. B. Taylor,
Julius Daniels, R. B. Thompson,
E. Y. Davidson, Jr., E. D. Tillson,
S. E. Doane, C. D. Wagoner,*
F. H. Gale,* H. F. Wallace,
Samuel G. Hibben, F. H. Winkley,*
Preston S. Millar, L. A. S. Wood.

*Not members of the Society but cooperating in the work of these committees.

SUSTAINING MEMBERS

Alexalite Co., New York, N. Y.
American Gas & Electric Co., New York, N. Y.
American Optical Co., Southbridge, Mass.
Amherst Gas Co., Amherst, Mass.
Bangor Railway & Electric Co., Bangor, Me.
Bausch & Lomb Optical Co., Rochester, N. Y.
Beardslee Chandelier Mfg. Co., Chicago, Ill.
Benjamin Electric Manufacturing Co., Chicago, Ill.
Boss Electrical Supply Co., Providence, R. I.
Boston Consolidated Gas Co., Boston, Mass.
Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Brooklyn Union Gas Co., Brooklyn, N. Y.
Cambridge Electric Light Co., Cambridge, Mass.
Central Electric Company, Chicago, Ill.
Central Hudson Gas & Electric Co., Newburgh, N. Y.
Commonwealth Edison Co., Chicago, Ill.
Consolidated Electric Lamp Co., Danvers, Mass.
Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Consolidated Gas Co. of New York, New York, N. Y.
Consumers Power Co., New York, N. Y.
Cooper-Hewitt Electric Co., Hoboken, N. J.
Corning Glass Works, Corning, N. Y.
Cox, Nostrand & Gunnison, Brooklyn, N. Y.
Cutler-Hammer Manufacturing Co., Milwaukee, Wis.
Dawes Brothers, Chicago, Ill.
Detroit Edison Co., Detroit, Mich.
Duquesne Light Co., Pittsburgh, Pa.
East Side Metal Spinning & Stamping Co., New York, N. Y.
Edison Electric Illuminating Co. of Boston, Boston, Mass.
Edison Lamp Works of General Electric Co., Harrison, N. J.
Electric Outlet Co., Inc., New York, N. Y.
Electrical Testing Laboratories, New York, N. Y.
Fall River Electric Light Co., Fall River, Mass.
Fitchburg Gas & Electric Co., Fitchburg, Mass.
Franklin Electric Light Co., Turners Falls, Mass.
Oscar O. Friedlaender, Inc., New York, N. Y.

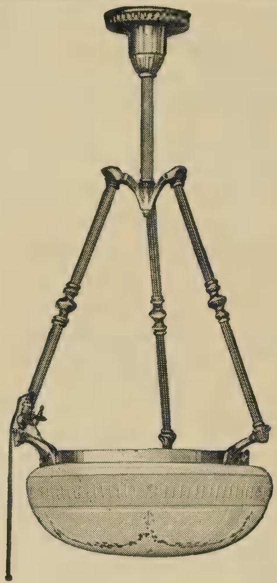
Gas and Electric Improvement Co., Boston, Mass.
Georgia Railway & Power Co., Altanta, Ga.
Gillinder Brothers, Port Jervis, N. Y.
Gillinder & Sons, Inc., Philadelphia, Pa.
Gleason-Tiebout Glass Co., Brooklyn, N. Y.
Gloucester Electric Co., Gloucester, Mass.
Greenfield Elec. Light & Power Co., Greenfield, Mass.
Fdwin F. Guth Co., St. Louis, Mo.
Hartford Electric Light Co., Hartford, Conn.
Haverhill Electric Co., Haverhill, Mass.
Holophane Glass Co., Inc., New York, N. Y.
The Horn & Brannen Mfg. Co., Inc., Philadelphia, Pa.
Hygrade Lamp Co., Salem, Mass.
Hydro-Electric Power Commission of Ontario, Toronto, Canada.
Irving & Casson—A. H. Davenport Co., Boston, Mass.
Krich Light and Electric Co., Newark, New Jersey.
Kristiania Elektrecitetsvork, Kristiania, Norway,
E. B. Latham & Co., New York, N. Y.
Lawrence Gas Co., Lawrence, Mass.
Leeds & Northrup Co., Philadelphia, Pa.
Lightolier Co., New York, N. Y.
Lundin Electric & Machine Co., Boston, Mass.
Lynn Gas & Electric Co., Lynn, Mass.
Macbeth-Evans Glass Co., Pittsburgh, Pa.
Malden Electric Co., Malden, Mass.
Malden & Melrose Gas Light Co., Malden, Mass.
McGraw-Hill Publishing Co., New York, N. Y.
Millville Electric Light Co., Millville, N. J.
Montpelier & Barre Light & Power Co., Montpelier, Vt.
Narragansett Electric Lighting Co., Providence, Rhode Island.
National Lamp Works of General Electric Co., Nela Park, Cleveland, Ohio.
National X-Ray Reflector Co., Chicago, Ill.
New Bedford Gas & Edison Light Co., New Bedford, Mass.
Newburyport Gas & Electric Co., Newburyport, Mass.
New England Power Co., Worcester, Mass.
New Haven Gas Gas Light Co., New Haven, Conn.
New York Edison Co., New York, N. Y.
New York & Queens Electric Light & Power Co., Long Island City, N. Y.

Pennsylvania Power & Light Co., Alltentown, Pa.
Peoples Gas Light & Coke Co., Chicago, Ill.
Pettingell-Andrews Co., Boston, Mass.
Philadelphia Electric Co., Philadelphia, Pa.
Philadelphia Electric Manufacturing Co., Philadelphia, Pa.
Pittsfield Electric Co., Pittsfield, Mass.
L. Plaut & Co., New York, N. Y.
Portland Railway, Light & Power Co., Portland, Ore.
Potomac Electric Power Co., Washington, D. C.
Providence Gas Co., Providence, R. I.
Public Service Corporation of New Jersey, Newark, N. J.
Public Service Company of Northern Illinois, Chicago, Ill.
Rochester Gas & Electric Corp., Rochester, N. Y.
Max Schaffer Company, New York, N. Y.
Salem Electric Lighting Co., Salem, Mass.
Shapiro & Aronson, Inc., New York, N. Y.
Slocum & Kilburn, New Bedford, Mass.
Societa Idroelettrica Piemonte, Turin, Italy.
Southern Electric Co., Baltimore, Md.
Sterling Bronze Co., New York, N. Y.
Stone & Webster, Boston, Mass.
Suburban Gas & Electric Co., Revere, Mass.
The United Gas Improvement Co., Philadelphia, Pa.
Charles H. Tenney & Co., Boston, Mass.
Tungsten Wire Works, A. B., Stockholm, Sweden.
Union Gas & Electric Co., Cincinnati, Ohio.
Union Light & Power Co., Franklin, Mass.
Union Electric Supply Co., Providence, R. I.
United Electric Light & Power Co., New York, N. Y.
United Electric Light Co., Springfield, Mass.
Alfred Vester Sons, Providence, R. I.
Welsbach Co., Gloucester, N. J.
Welsbach Street Lighting Co., Philadelphia, Pa.
Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
Westinghouse Lamp Co., Bloomfield, N. J.
Wetmore-Savage Co., Boston, Mass.
Worcester Electric Light Co., Worcester, Mass.
Worcester Suburban Electric Co., Palme r,Mass.

OFFPRINTS ORDERS

In order to minimize the expense of holding type, the printer has been instructed to throw the pages of the TRANSACTIONS shortly after publication. Authors wishing to secure offprints at the minimum rate should notify the General Office in advance. For offprints ordered after publication in the Transactions, a higher fee must be charged.

COMMITTEE ON EDITING AND PUBLISHING



PILLARS of IRON-
the very embodiment of strength!
"Pillars of iron"—Westinghouse Ornamental Street Lighting Posts are more than just that. They are made of a special mixture of grey iron, possessing the same rust-resisting qualities as foundry iron and have shock-resisting properties characteristic of malleable iron.
Graceful, uassumingly beautiful, Westinghouse posts have been designed to withstand the wear of time and weather as well as to repel the buffets of wayward traffic.
Witness: An Arcadian Post at Chillicothe, Ill., after it had been struck by an automobile with sufficient force to displace the foundation. The glassware is broken but the post, representing the larger part of a street lighting investment, is undamaged.
For complete information on any street, boulevard or park lighting problem, write to
Westinghouse Electric & Manufacturing Company
George Cutter Works South Bend, Indiana
W
WESTINGHOUSE ELECTRIC
Westinghouse

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

OFFICE OF PUBLICATION: 125 W. STATE ST., ITHACA, N. Y.

Published monthly except June and August under the direction of the Committee on Editing and Publication.

DATES OF PUBLICATION

No. 1, January — No. 2, February — No. 3, March
No. 4, April — No. 5, May — No. 6, July
No. 7, September — No. 8, October — No. 9, November
No. 10, December

SUBSCRIPTION, $7.50 PER ANNUM — SINGLE COPIES $1.00
FOREIGN SUBSCRIPTION $8.00 PER ANNUM

ADVERTISING RATES MAY BE HAD UPON APPLICATION
TO THE GENERAL OFFICES OF THE SOCIETY
29 WEST 39TH STREET, NEW YORK, N. Y.

ENTERED AS SECOND CLASS MATTER AT THE ITHACA, N. Y. POST OFFICE
ACCEPTANCE FOR MAILING AT SPECIAL RATE OF POSTAGE PROVIDED FOR
IN SECTION 1103, ACT OF OCTOBER 3, 1917, AUTHORIZED JULY 16, 1918